OCEAN DRILLING PROGRAM

LEG 132 PRELIMINARY REPORT

ENGINEERING II: WESTERN AND CENTRAL PACIFIC

Mr. Michael A. Storms
Supervisor of Development Engineering
Ocean Drilling Program
Texas A&M University
College Station, Texas 77845

Dr. James H. Natland
Chief Scientist
Scripps Institution of Oceanography
La Jolla, California 92093

Philip D. Rabinowitz
Director
ODP/TAMU

Barry W. Harding
Manager of Engineering
and Drilling Operations
ODP/TAMU

Timothy J.G. Francis
Deputy Director
ODP/TAMU

September 1990

This informal report was prepared from the shipboard files by the engineers and scientists who participated in the cruise. The report was assembled under time constraints and is not considered to be a formal publication which incorporates final works or conclusions of the participants. The material contained herein is privileged proprietary information and cannot be used for publication or quotation.

Engineering Preliminary Report No. 2
First Printing 1990

Copies of this publication may be obtained from the Director, Ocean Drilling Program, Texas A&M University Research Park, 1000 Discovery Drive, College Station, Texas 77845-9547. In some cases, orders for copies may require payment for postage and handling.

DISCLAIMER

This publication was prepared by the Ocean Drilling Program, Texas A&M University, as an account of work performed under the international Ocean Drilling Program, which is managed by Joint Oceanographic Institutions, Inc., under contract with the National Science Foundation. Funding for the program is provided by the following agencies:

Canada/Australia Consortium for the Ocean Drilling Program
Deutsche Forschungsgemeinschaft (Federal Republic of Germany)
European Science Foundation Consortium for the Ocean Drilling Program
(Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland, and Turkey)
Institut Français de Recherche pour l'Exploitation de la Mer (France)
Ocean Research Institute of the University of Tokyo (Japan)
National Science Foundation (United States)
Natural Environment Research Council (United Kingdom)

ENGINEERING/OPERATIONS REPORT

Engineering and Operations personnel aboard *JOIDES Resolution* for Leg 132 were:

Michael A. Storms, Supervisor of Development Engineering (Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, Texas 77845-9547)
Fulton Blanchard (Schlumberger Offshore, Box 25, Weldon Road, Houma, Louisiana)
Jean-Baptiste Fay (Institut Français du Petrole, 1 et 4, av. de Bois-Preau BP 311, 92506 Rueil Malmaison, Cedex, France)
Glen Foss (Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, Texas 77845-9547)
G. Leon Holloway (Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, Texas 77845-9547)
Steven P. Howard (Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, Texas 77845-9547)
Dietmar Krehl (Eastman Christensen GmbH, P.O. Box 309, Christensenstrasse 1, D-3100 Celle 1, West Germany)
Ralf Luy (Institut für Tiefbohrtechnik, Erdöl- und Erdgasgewinnung (ITE), Agricolastrasse 10, D-3392 Clausthal-Zellerfeld, Federal Republic of Germany)
Charles N. McKinnon, Jr. (Consultant, Downey, California)
Brian D. Mordaunt (DRECO Inc., Building H-4, P.O. Box 1624, Freeport Center Clearfield, Utah 84016)
Daniel H. Reudelhuber (Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, Texas 77845-9547)
Masataka Zaitsu (Nippon Marine Enterprises, Ltd., 6F Yokosuka Dai-ichi Building, 2-18 Ohtakicho, Yokosuka, 238, Japan)

Ondo Experiment

Asahiko Taira (Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo, 164, Japan)
Hiroshi Matsuoka (Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo, 164, Japan)
Hideyuki Murakami (2-17-3 Kasumigaseki Kita, Kawagoe, Saitama, Japan)

ABSTRACT

The primary goals of Leg 132 (Engineering Leg 2) were to test the Phase II version of the ODP developmental diamond coring system (DCS), a new drill-in bottom hole assembly (DI-BHA), and a new hard rock base (HRB) seafloor structure for bare rock spudding. While the DCS was originally tested on Leg 124E (Engineering Leg 1), the drilling and seafloor hardware consisted of prototype designs being deployed and tested at sea for the first time. The original objective of coring with the DCS in three distinctive geological environments on Leg 132 was not met due to time lost early in the leg associated with required refinement and modification of the prototype drilling/seafloor hardware. This equipment was eventually made functional and the test data gained will lead to more efficient and vastly superior operating capabilities on future scientific legs. The DCS itself was proven capable of successfully drilling and coring in fractured crustal material as well as maintaining stable hole conditions in formations hertofore deemed "un-drillable." Data obtained during the drilling will also lead to improved flexibility and performance in the coring system's core retention capabilities. From an engineering standpoint the data gained throughout the leg will be of critical importance to the continued development and eventual success of future scientific coring operations in hostile environments.

INTRODUCTION AND BACKGROUND

Leg 132 was the second of an anticipated sequence of cruises designed to support the development and refinement of the hardware and techniques necessary to meet the ODP scientific mandate of the future. As the technical complexity required to tackle high-priority scientific problems continues to grow, so too does the demand for dedicated ship time enabling the required technology to be developed, tested, and refined to an operational level. Although the Ocean Drilling Program continues to emphasize comprehensive shore-based testing of developmental equipment, these tests cannot adequately simulate the offshore marine environment in which the tools will ultimately operate. Engineering legs are therefore essential to the successful attainment of the required technology.

During Leg 132, we thoroughly field tested a second-generation mining-type diamond coring system (DCS) designed for deep-water drilling, and two new types of seafloor reentry assemblies. A complete set of tests was conducted in one environment where previous rotary coring had proven inadequate to recover young, fractured basalts at an unsedimented spreading ridge (Bonin backarc basin), and partially carried out in another with alternating hard and soft chert-chalk sequences in the Mesozoic western Pacific (Shatsky Rise). Drilling in fractured basalt provided the initial impetus for developing the DCS. Two full legs of the Ocean Drilling Program, 106 and 109, had previously been devoted to an unsuccessful attempt to establish a deep hole in the axial rift of the Mid-Atlantic Ridge (Detrick, Honnorez, Bryan, Juteau et al., 1988). Although a hole was spudded into bare rock for the first time using a hard-rock guide base (Site 648), only 50.5 m of basalt was penetrated using rotary coring, recovery was very low, sidewall stability was a continual problem, and the hole ultimately was abandoned. That simply confirmed previous experience with rotary coring in very young ocean crust at thinly sedimented ridges during Deep Sea Drilling Project Legs 34 (Yeats, Hart, et al., 1976), 49 (Cann, Luyendyk, et al., 1979), and 54 (Natland and Rosendahl, 1980).

Accordingly, based on recommendations of the JOIDES Technology and Engineering Development Committee, Lithospheric Panel, and Planning Committee, the Ocean Drilling

Program undertook adaptation of high-speed diamond coring technology, used successfully in fractured rock on land by the mining industry, to the deep-sea environment and the particular configuration of the drilling vessel *JOIDES Resolution (SEDCO/BP 471)*. A DCS prototype was tested in January 1989 at sea near the Philippines during Leg 124E (Harding, Storms, et al., 1990). Then followed 14 months of development of new top-drive and heave-compensation systems, as well as of seafloor installation hardware to provide opportunities for DCS coring at both unsedimented and sediment-covered locations.

Leg 132 was the first full-scale operational field testing of the integrated systems. In this report we provide a review of the results of these engineering tests, a discussion of the new system components tested during Leg 132, and a background for the engineering objectives of the leg. We them present a brief summary of the engineering tests and operations undertaken at each of the drillsites. Leg 132 scientific objectives are given in the "Scientific Report" that follows this "Engineering and Operations Report." All figures referenced in this report follow the "Scientific Report."

REVIEW OF ENGINEERING I (LEG 124E) TEST RESULTS

Diamond coring as practiced by mining companies on land makes use of three principles to recover fractured rock: (1) small hole diameter, (2) high rotation speed with a narrow-kerf diamond bit, and (3) uniform low weight on bit. The prototype system tested on the first ODP engineering cruise, Leg 124E, cut a 4-in. hole (compared with 9-7/8 in. by rotary coring), at 60-120 rpm (vs. 45-75 rpm for rotary coring), with 2000-5000 lb weight on bit (vs. 25,000-45,000 lb for rotary coring). Fluctuations in weight on bit were less than 500 lb, whereas in typical rotary coring they may reach ±30,000 lb.

To undertake high-speed diamond coring at sea on *JOIDES Resolution* during Leg 124E, a high-speed hydraulically driven top drive and control system were installed in the rig. A special platform was constructed from which to suspend a long tubing string with a 4-in.-diameter bit for drilling at the end; the entire length of tubing was rotated by the top drive. The thin-walled tubing string was laterally supported by running it through standard drill pipe which extended from the ship to the seafloor. The platform itself was suspended below the ship's primary heave compensator in the derrick. To reduce residual heave even further, to within appropriate limits for diamond coring, a separate secondary heave-compensation system was configured to act on the tubing string alone.

Leg 124E sailed with several objectives, one of which was to test the new concept of high-speed diamond coring in basaltic basement. The leg demonstrated the technical feasibility of the DCS, although coring in basalt was not accomplished. State-of-the-art "high-tech" sensor technology, coupled with a microprocessor unit, were used to drive the secondary heave-compensation system. The system was designed to maintain extremely accurate control of weight on bit (± 500 lb). The DCS heave-compensation system was effective in maintaining accurate weight-on-bit control even under extreme weather conditions. A 3-1/2 in. outer-diameter (O.D.) tubing string, with Hydril series 500 wedge-lock threaded connections, was used as a work string inside the ODP API 5-1/2-in. drill pipe. The tubing string performed well, with no failures or detectable wear occurring while rotating the string at 60 to 120 revolutions per minute (rpm). The skidding and storage of the fully assembled diamond coring system platform back from well center, when not in operation, proved effective. Though space beneath the derrick was limited, it was possible to trip drill pipe conventionally using the iron roughneck (make-up, break-out unit) while the DCS platform was positioned to the starboard side of the rig floor. Though only limited coring operations were performed, the viability and utility of deploying a diamond coring system from a floating vessel were clearly demonstrated from both technical and operational viewpoints.

Drilling an exploratory pilot hole with the ODP 5-1/2-in. drill string and deploying the diamond coring system through the drill string, with the large bit remaining on bottom in open hole, was only partly successful. Because of the limited amount of overhead clearance in the derrick, the large roller-cone bit had to be drilled to a precise depth, providing proper spacing for the top-drive/heave-compensator traveling assembly. Had the drill pipe become stuck off bottom while tripping in the 3-1/2-in. tubing work string or while rigging up the DCS platform, it would have been necessary to free the stuck drill pipe before continuing with the diamond coring operation. Deploying the DCS coring assembly through the 11-5/8-in. extended core barrel (XCB) bit positioned 15-20 ft off bottom could have buckled the 3-1/2-in. tubing in the open hole below the bit. Had that happened, the rotating tubing would have made contact with the 11-5/8-in. XCB roller cones.

Because it was necessary to move the bit on and off bottom during deployment and during the DCS core-bit run, good hole stability had to be maintained. Lack of good hole stability hampered the deployment and testing of the DCS throughout Leg 124E. A total of 16-1/2 days was allocated to testing the DCS. Fifty-one percent of this time was spent en route to prospective sites and drilling/coring seven holes ranging in depth from 6 to 361 meters below the seafloor (mbsf). The larger diameter holes were drilled in an effort to establish a borehole penetration near basement that would be stable enough for deployment of the DCS. For the DCS to be used effectively as a scientific coring system, a means to provide upper hole stability (in sediments as well as in fractured rock) had to be devised.

Though only 5% of the allotted time on Leg 124E was actually spent coring with the DCS, five cores were successfully cut. The material cored was clay and silty clay. Though the DCS core bits run were specifically designed for coring basalt, the clay cores recovered demonstrated that soft formations also can be cut effectively. One core in particular (124E-773B-4M) was deemed by several of the shipboard scientists to be of excellent quality for a sediment core, having little drilling disturbance. A total of 7% of the time was spent in tripping tubing. The remaining 36% of the time was spent in rigging and handling the DCS platform on the rig floor and in the derrick.

Though the objective to core in basement (basalt) was not accomplished during Leg 124E, a significant amount of operational and technical information was obtained. The DCS was deployed in weather and heave conditions that in many instances exceeded the original design parameters. The handling and operational characteristics of the core-drill platform were well defined. As a result of the DCS testing on Leg 124E, modifications to the DCS platform, secondary heave compensator, and coring equipment were made that allowed the system to be streamlined and made more efficient for Leg 132 operations.

SYSTEM COMPONENTS

The DCS used during Leg 124E was developed and configured in the most inexpensive mode possible. The program was very limited in scope and there was little test time. Thus, the "Phase I" test of the DCS system represented only a conceptual evaluation or feasibility study. The hardware was not suitable for achieving any full-scale scientific or engineering goals. Nevertheless, with the potential of the system established on Leg 124E, several important new features were incorporated into the design of the DCS. The new system, tested on Leg 132, is referred to as the "Phase II (4500-m)" system. It was the first viable attempt at fully evaluating the system components and achieving limited scientific goals. Although operations during Leg 132 reached only to 1900 m below sealevel, the system is designed to operate with up to 4500 m of tubing suspended from the DCS platform.

A major, Phase-II innovation was development of an electric top drive to replace the more cumbersome and less responsive hydraulic top drive used during Leg 124E. The heave-compensation system was greatly modified, and two new seafloor structures were designed and constructed to allow drilling on unsedimented volcanic rock and in formations covered with sediment. Finally, a drill-in bottom-hole assembly (BHA) was designed to leave in the hole and stabilize the upper, more fractured formation.

Diamond Coring System Platform Assembly

The DCS built for Leg 132 (Fig. 1) also involved running small-diameter, high-strength, 3-1/2-in. tubing inside 5- and/or 5-1/2-in. drill pipe, which provides lateral support for the tubing to the seafloor. A high-speed, thin-kerf, diamond core bit (3.96-in. OD X 2.20-in. I.D.) is attached to an outer core-barrel assembly on the end of the tubing string. The core barrel is a modified Longyear HQ-3 type, specially developed for this application. The core barrel is capable of recovering 10.0-ft x 2.20-in. cores in acetate butyrate core liners.

The tubing string is driven with an electric top drive capable of operating at speeds of up to 540 rpm. The new, 800-horsepower, electric version is capable of producing higher torque (11,000 ft-lb) and has a larger load-carrying capacity than the leased prototype hydraulic top drive used on Leg 124E.

The most important consideration when coring with the DCS is precise control of weight on bit, accomplished by using a secondary heave compensator (Fig. 2). The secondary compensator removes load fluctuations resulting from the mechanical inefficiencies of the primary 400-ton passive heave compensator. It is arranged in series beneath the larger compensator. This system is intended to provide control for weight-on-bit fluctuations of ±500 lb and compensate for residual vessel heave of ±12 in. at the DCS platform. The secondary heave compensator is rated for 150,000 lb of tubing string weight.

Another important consideration when coring with the DCS is precise control of mud flow and pressure. That was accomplished on Leg 132 by installing 4-in. liners in one of the standard triplex-rig mud pumps and by designing special control circuitry, allowing very slow and precise operation of the pump from the DCS platform. That important design feature allows the driller to identify core blockage or other downhole problems, thus allowing maximum core recovery.

All diamond coring operations and drilling functions are performed from the manned platform suspended in the derrick about 14 m above the rig floor. A control console is situated on the platform to allow operation of the DCS drilling systems. The platform is picked up once the hard-rock guide base or modified reentry cone is installed, and the drill pipe with the DCS tubing string inside is connected and tensioned up.

The platform is put into operation by tripping the remaining tubing (3-m drilling joints) to just above the bottom of the borehole, then activating the secondary heave compensator and automatic feed system. The diamond core bit automatically advances to the bottom of the borehole and the desired bit weight is established for the coring run. When the coring run has been completed, the bit retracts off bottom, and the inner barrel with core is retrieved by means of a wireline. Coring operations can resume once an empty inner barrel is pumped down, landed, and properly latched into the outer barrel.

The DCS platform used on Leg 132 is a modified version of the one used on Leg 124E. The platform is approximately 45 ft tall and weighs 40 tons. The work area inside the platform is approximately 8 x 12 ft, allowing two to three workers to move about comfortably during coring operations. The platform is stored out of the way on the rig floor and rolled into position by means of a moveable dolly/track system when required. Power to operate the console top drive and secondary heave compensator is supplied by two electrical umbilicals.

Sea-Floor Structures

The two types of seafloor structures used during Leg 132 were developed specifically for use with the DCS. Both structures were deployed and tested during the leg. The new "mini" hard-rock base (HRB) is equipped with a gimbaled reentry cone, allowing the structure to be placed on an irregular or sloping seafloor and still retain a vertical orientation for the reentry cone (Fig. 3). The cone itself is free to swing on the gimbal but is held to the vertical by buoyant syntactic foam panels strapped to the outer walls of the cone. The base can be set on seafloor with a slope of up to 20°, and the cone will still pivot to a vertical position.

A specially modified reentry cone (Fig. 4) was also developed to conduct DCS operations in areas where there is sufficient sediment to allow washing in the cone and casing more conventionally.

With either system, the drill string is lowered into the cone to a landing seat, then rotated clockwise (jayed-in) to lock the end of the string into the cone. During coring operations, the drill string is pulled in tension (to 50,000 lb) against the weight of the guide base or, in the case of the reentry cone, against the skin-friction of a washed-in BHA.

Tensioning/Mini-Riser System

In addition to the DCS and seafloor structures, several other pieces of hardware and concepts had to be developed and refined. Those included use of the 5- and 5-1/2-in. drill pipe as a mini-riser, tensioning tool, tapered stress joint, and a modified J-type casing hanger. The systems all work in tandem with each other, allowing the 5- or 5-1/2-in. drill string to be attached to a seafloor structure and tensioned.

The DCS tubing string requires lateral stabilization in order to be deployed in deep water. To accomplish that, the outer string is held in tension by exerting a tensile over-pull on a weighted or otherwise anchored sea-floor structure. In providing the required lateral support, the primary 5- or 5-1/2-in. drill string acts much like a smaller version of an oil-field riser, hence the term "mini" riser. Although no attempt was made during Leg 132 to return cuttings to the ship, which is also the function of a riser, this capability is potentially there for future operations.

To attach the drill string to the structure, a modified J-type latching device or tensioning sub was designed and built. The concept of using a riser to support drilling operations is not new, but the small size and length that ODP require make the operation unique. Typical over-pull tension on either seafloor structure is 35-40 tons.

A tapered stress joint was also developed as an integral part of the required tensioning system. The specially designed, 30-ft long, tapered drill collar is placed on top of the tensioning sub just above the jay-slot in the reentry cone (Fig. 5). It is required to take out, or at least reduce, any lateral moment introduced by vessel offset during DCS drilling operations. The entire mini-riser tensioning concept required a thorough dynamic riser analysis before any of the equipment was designed. The analysis proved critical not only for the design of the stress joint and tensioning sub but also for the feasibility of performing deep-water DCS coring operations.

Drill-in BHA System

To allow DCS coring operations to progress once a seafloor structure is deployed, a mechanical back-off device that releases a drill-in bottom-hole assembly (DI-BHA) had to be developed. The device operates when the BHA is drilled in to the point at which it is stopped by a landing shoulder in the casing hanger. Continued rotation of the drill string then unthreads the BHA, freeing it from the rest of the drill string (Fig. 6).

The device allows the flexibility of drilling through hard, fractured rock where hole instability prevents conventional casing strings from being set. The DI-BHA itself serves as a casing, isolating unstable formations in the upper part of a hole which otherwise might prevent drilling with the DCS. The DI-BHA is inserted into the formation by drilling through the HRB or modified reentry cone using a mud motor placed above the BHA and back-off assembly. Once the DI-BHA is drilled to a predetermined depth, the back-off sub beneath the mud motor is activated, releasing the lower portion of the DI-BHA. A test hole drilled prior to setting the seafloor structure is required to ensure that some minimum attainable depth can be reached for the DI-BHA. That allows proper placement of the back-off assembly within the BHA.

LEG 132 ENGINEERING OBJECTIVES

The primary engineering goals for Leg 132 included the evaluation of the DCS in problematic geologic environments and the testing of new techniques for spudding and controlling unstable formations. As such, the test plan for Leg 132 focused on the ability to spud a hole on bare rock, stabilize fractured or unstable formations, and deploy the DCS for coring operations in crystalline rock and interbedded chalk/chert formations. Plans to also drill shallow-water lagoonal and reefal limestones on a submerged atoll were not carried out because of engineering and operational requirements during the leg.

The principal engineering objectives of Leg 132 were the following:

1. Evaluate the overall performance and efficiency of the redesigned DCS in water depths ranging from 1000 to 3000 m. The DCS was evaluated in two distinctive geological environments: (1) bare and/or fractured crystalline rock, and (2) interbedded chalk/chert sequences.

2. Deploy and test the new "mini" HRB designed for more efficient and economical spudding on bare and/or fractured rock.

3. Deploy and test a modified reentry cone designed for compatibility with the DCS.

4. Evaluate developmental techniques and hardware for establishing and maintaining upper hole stability, allowing successful deployment of the DCS for scientific coring operations in unstable formations.

5. Evaluate the HRB or reentry-cone/API-drill-string tensioning system for use as a drill-string mini riser.

Specific engineering and operational objectives included the following:

Mini Hard Rock Guide Base/Upper Hole Stabilization

1. Test gimbal concept for greater rotational freedom of reentry cone.

2. Evaluate use of weighted cement (with iron ingots) for ballast.

3. Evaluate use of ODP's API drill pipe as a mini riser in deeper water and at higher rpm than was attempted on Leg 124E.

4. Install and evaluate performance of a new tapered stress joint above the breakaway mechanical tensioning device.

5. Evaluate use of a mechanical tensioning tool to hold tension on guide base.

6. Test modified 16-in. casing hanger designed to accept the mechanical tensioning tool and landing seat for the back-off sub.

7. Evaluate drill-in/back-off release mechanism, allowing use of BHA for bare fractured rock spudding and upper hole stabilization.

8. Evaluate adaptation of mini-riser tensioning system to standard reentry cone design.

Diamond Coring System 4500-m Capability (Phase II)

1. Continue evaluation of DCS in an offshore environment.

2. Operate and evaluate an upgraded and modified version of the HQ-3 core-barrel system.

3. Test redesigned heavy-duty, self-winding wireline winch for core-barrel retrieval.

4. Operate and evaluate upgraded dual-cylinder secondary heave-compensation system with simplified computer network.

5. Evaluate use of safer, operationally improved DCS platform.

6. Operate and evaluate new electric top-drive system with higher load and higher torque capability.

7. Deploy and evaluate high-strength tubing (DCS core string) in a production mode and locate nodal vibration points at varied rpm and string lengths.

8. Evaluate new umbilical design for DCS platform.

9. Evaluate new upgraded DCS mud-pump system.

10. Evaluate performance of new hybrid drill-in bit for drilling BHA into fractured basalt.

LEG 132 ENGINEERING TEST SITES

Leg 132 departed Pusan, Republic of Korea, on 8 June 1990 and arrived in Guam on 5 August 1990. The leg was 59 days in duration and conducted engineering test operations in two distinct areas of the western and central Pacific Ocean (Fig. 7). Two sites, 809 and 810, were occupied (Table 1). The sites were selected to maximize the value and efficiency of the engineering test objectives but at the same time provided an opportunity to obtain valuable scientific information in these selected areas.

Site 809 (31°03'N, 139°53'E, water depth 1802 m) is located east of Kyushu and south of Yokohama, Japan, in the Bonin backarc basin (Fig. 8). The site was occupied for 36 days while evaluating the "mini" HRB, bare-rock spudding/hole-stabilizing techniques, and performance of the improved Phase II (4500 m) DCS in fractured basalts as a prelude to future scientific operations at unsedimented spreading ridges (e.g. East Pacific Rise).

Site 810 (32°25'N, 157°50.7'E, water depth 2634 m) is located approximately 912 nmi east of Site 809 on Shatsky Rise near DSDP Sites 47, 305, and 306 (Fig. 9). Nine days were planned at this site to emplace a modified reentry cone/casing system on the seafloor and carry out DCS coring in interbedded Mesozoic cherts and chalks.

LEG 132 ENGINEERING AND OPERATIONS

<u>Ondo Tool Deployment at Site 808, Nankai Trough</u>

After leaving Pusan, Republic of Korea, at 0800 on 8 June 1990, we first sailed to Nankai Trough, east of Japan (Fig. 7), to complete some unfinished business of Leg 131. Three participants from that prior leg remained on board, including A. Taira, one of the Leg 131 Co-Chief Scientists, to carry out the work. The assignment was to lower a complex temperature probe (ONDO tool) through a reentry cone into Hole 808E, which was drilled through a décollement at the Nankai accretionary prism. Several attempts to lower this tool during Leg 131 had not succeeded because the dimensions of the tool were too large. Modifications were made during the Pusan port call, and the tool was successfully emplaced in the hole during Leg 132 on 11 June. The full operational account of that is given in Taira, Hill, et al. (in press).

We then proceeded to our first engineering test site on the Sumisu Rift, arriving in the early morning of 13 June. A boat came out to retrieve the three Leg 131 personnel from Leg 131 on 15 June.

Site 809 (Bonin Backarc Basin)

13 June-25 June, 1990: Initial Hard-rock Base Installation

During the approach to Site 809 (Fig. 7), we passed north-south over the crest of a line of small volcanic ridges to locate ourselves precisely within the Hawaii Institute of Geophysics SeaBeam bathymetric survey (Taylor et al., in press). The site was chosen to be as close as possible to the crest of the ridge at a saddle between two of the small peaks, the area appearing to offer the flattest seafloor for setting of a guide base. The crest line at the low point of the saddle was precisely located on an east-west pass, and the beacon was dropped there on the return pass. Currents carried the beacon about 150 m to the southeast before it reached the seafloor (Fig.8).

Two short surveys of the seafloor were carried out using a Mesotech acoustic scanner and a TV camera, one before each of the first two holes we drilled. The seafloor consists of slightly sedimented scoriaceous pillow lava, with pillow diameters ranging from less than 0.5 to more than 2 m. The beacon itself was located near a 10-m-high flow front, but the flow is fairly flat upslope to the west. Here, 30 m south and 34 m west of the beacon, we spudded our first hole, Hole 809A, which was drilled using the positive-displacement coring motor to test the capability of a newly designed 11-5/8-in. bit/center-bit assembly in coring volcanic rock. Using the coring motor, and 2000-5000 lb of weight on bit, the hole reached 8.3 mbsf in 7 hr, a penetration rate of 1.2 m/hr. No cores were taken. Wear on the bit was negligible. The TV monitor revealed a crater about 2 m in diameter around the pipe, indicating that caving had occurred around the top of the hole. The caving was probably aggravated by the "whipping" action of the coring motor during the unsupported spudding operation.

The next test hole, Hole 809B, was drilled in the same manner with a smaller newly designed bit 9-7/8-in. diameter, again with a center bit. The hole was about 100 m farther to the northwest, on a similar but probably somewhat older flow of pillow lavas, with ponded sediment between the pillows. Here, closer to the presumed rift axis, we hoped for smoother drilling conditions and even less basement relief. The bit indeed produced a narrower hole (<1 m diameter) with less caving, and reached 13.4 mbsf in 8.3 hr, a penetration rate of 1.6 m/hr. Again, bit wear was negligible. Using the Mesotech acoustic scanner, we identified a particularly flat area away from local flow fronts or pillow ridges that produced backscatter shadows of 2-3 m at distances of 20-30 m on the display. The coordinates of the flat patch relative to the beacon were noted for reference during the guide-base operation. This was fortunate, because the Mesotech scanning sonar failed during the guide-base lowering and did not function thereafter.

The guide base, which during that time was being constructed over the moonpool, was lowered to start Hole 809C and reached the seafloor at 1100 hr on 16 June. Setting the base on the seafloor was done blindly, since the vibration-isolated television (VIT) frame holding the TV camera was unable to see below the guide base to the bottom. With the weight of the base released from the drill string, we disconnected the pipe by rotating the jay-tool and backing out of the cone. To our great surprise, the cone quickly lurched away from the camera to one side, and then leaned into one corner of the central cavity within the hard-rock base. Initially, we feared that the basement surface was too steep, but examination of video tapes and subsequent operations established instead that the problem was insufficient syntactic foam to provide buoyancy to right the cone to a vertical position above its gimbal assembly. With the jay-tool still down, we did a test reentry and used the weight of the drill string plus the ship's dynamic positioning system to pull the cone upright.

With some reentry capability established, we retrieved the pipe and ran in with a core bit and drill-in BHA. The design was intended to case off about 6 m of hole and thus provide sidewall stability at the outset of diamond coring operations, and simultaneously to lock the cone into a vertical position. After drilling 6 m, the pipe was to separate automatically from the BHA by means of a tapered back-off sub, leaving the lower portion of the BHA in the hole and below the jay-slot. Unfortunately, the back-off sub rotated free after only 4.1 m of penetration at Hole 809C, leaving the top of the casing above the bottom of the J-slot. That was confirmed during our next reentry with the J-tool.

We tripped the pipe and sent down a tool to fish the BHA. The reentry and fishing operation went smoothly, but the cone freed of the supporting casing once again fell to the south corner of the weighted base. We elected this time to drill a "rat-hole" into which the same backoff system could simply be lowered without fear of premature operation of the back-off sub. However, on this reentry attempt, we had great difficulty in pulling the cone upright. We managed to get into the throat of the cone, but at an angle that did not allow the BHA to pass through the casing hanger to the seafloor. Reentry in this circumstance requires pivoting the cone to a nearly upright position, and then working the bit into the casing hanger. Alternatively, the string can be slid down one side of the inclined cone at an angle (produced by draping the pipe into the cone by means of offsetting the ship). It is hoped that the angle can come close to that of the gimbaled casing hanger. The risk is that such operations can produce strong excursions of the cone about the pipe as it rotates about its gimbal assembly. The situation was exacerbated by rocking of the weighted base itself on two legs as the cone swung and lurched into the sides of the box. This is because the four-legged base can only sit on three legs on an irregular basement surface. Bit weight on the sides of the cone applies moments to either side of the base which is centered on a line between the two stable legs, thus, it must wobble.

During one such pirouette on this reentry attempt, the cone swung out of a pinned position, and the drill string itself fell away, imparting a sharp lateral blow to the inner lower surface of the cone. That caused the cone to separate partially from its welded base and gusset support assembly where it joined the casing hanger. The cone could not safely be reentered in that condition, so we elected to push it completely off the casing hanger, using the drill string. The cone fell to the seafloor upside down, confirming that the flotation was inadequate to support the cone even without that portion of the casing hanger above the gimbal.

The casing hanger itself, however, offered a small, 24-in. diameter opening through which reentries might be accomplished. The hanger would still have to be pulled to an upright position, but there was no reason why we should not attempt it.

Regrettably, although we were able to put the end of the string into this tiny opening several times, and with more than one configuration of a BHA during two additional pipe trips, we never succeeded again in getting the drill-in BHA past the J-tool assembly. Almost certainly, this was because we could not hold the end of the string in the top of the hanger and relieve enough weight to drag it into a vertical position. The rocking hard-rock base complicated these attempts.

At this point, our discussions turned to abandoning this guide base and setting the other one on board onto the seafloor. The flotation problem still existed, however. The only way to solve it was to retrieve the inverted cone with its flotation foam from the seafloor and use it together with the foam for the second guide base, all on one assembly. A fishing tool with four arms arranged like a moly-bolt was lowered to the seafloor and speared through the inverted opening at the cone's base. The simple tool worked well, and the cone was back on deck within a few hours.

Emboldened by that success, we decided to fish for the guide base. If it could be retrieved, then we would not lose the site planned for the second guide base later in the leg. A double J-tool was lowered on flexible 5-in. drill pipe. No other BHA components were used. The hard-rock base was located with the TV, and the 24-in. opening in the casing hanger reentered. The hanger was pulled from the south to the north corner of the base by offsetting the ship to allow a maximum alignment of the flexible pipe with the tilted end of the hanger. After rotating the J-tool with the coring motor, we finally found an orientation which allowed it to slip into the J-assembly. Another partial turn engaged the tool, and we lifted the guide base from the sea floor to the moon pool.

Once on deck, the reincarnated guide base was refitted by lightening the cone, doubling up the foam, and reattaching the cone to its base. We constructed a tilt beacon to be assured that the base would rest on sufficiently flat bottom, and added markings and inclinometers to the base to determine its orientation after we disconnected from the cone. The base with its cone was then returned to the depths and landed. The base on the new hole (Hole 809D), had a 15° slope on a pillowed surface, and the cone floated in an upright attitude from its gimbal.

25 June-18 July, 1990: HRB Maneuvering and DCS Coring

After lowering the reconstructed guide base, several additional difficulties with the seafloor installation had to be overcome before we established a viable hole at Site 809. At Hole 809D, although we succeeded in emplacing the drill-in BHA in the casing hanger and stabilizing the reentry cone, a failure of the J-tool left a 6-in. slab of metal in the throat of the guide base. The damaged tool was retrieved and the remaining tool strengthened. It was then tripped back down to the cone, jayed in, and tused to lift the base over the drill-in casing, leaving the casing embedded in the seafloor. We moved the hard-rock base a few meters to Hole 809E. Using the TV monitor, we saw the metal slab resting on top of the drill-in BHA after we lifted the base.

At Hole 809E, after some hours attempting to drill in another BHA, we eroded and undercut the basalt underlying one leg of the hard-rock base, causing it to tilt beyond the 20° maximum allowed by the reentry-cone gimbal assembly. We retrieved the casing, tripped back to the cone, jayed in, and moved the base across the seafloor to a new location Hole 809F) where we succeeded in drilling in and latching a BHA to a depth of 5.9 mbsf.

There followed a period of assembly and testing of the DCS rig. Several problems were discovered with the secondary heave compensation system, most of them having to do with noise imparted to controlling accelerometers mounted on the DCS platform. The most serious complications were resonance sent down the pipe (which was held in tension against the weight of the hard-rock base) and returned to the ship, and noise from the DCS platform's hydraulic feed cylinders. Both would change sometimes hourly as sea state, wind, and ship's orientation changed. Eventually, the problem was overcome by shifting the sensor system to a bulkhead next to the moonpool, thereby bypassing the fluctuating, high-frequency motions of the platform and hydraulic system. For most of the time we were coring, however, the full heave compensation system was not in use.

Coring with the DCS began on 6 July. Adjustments had to be made to input parameters in the controlling computer program, inasmuch as changes in weight on bit caused simply by landing the bit on the bottom of the hole were initially interpreted by the computer as break-throughs in the formation ("void hits"). That triggered automatic pull-backs of the drill string. Also, about 2 m below the bottom of the casing, we encountered what we interpret as a flow-top breccia, which was extremely quickly drilled and which took almost no weight on bit. Virtually none of the material was recovered, evidently because it was either washed out ahead of the bit by down-the-pipe circulating fluids or because it fell out of the core barrels as they were retrieved. Throughout this time, there were several indications of possible core jams, based on pressure readings of the drilling fluid pumped down the tubing. At least one such reading may have been caused by aggregation of lumps of gel separated from the lubricant added to the drilling fluid. Also, some core barrels may not have latched in because of accumulated debris (lost core) lodged above the bit. We finally concluded that our core barrels indeed were functioning properly but that the formation itself was too friable to be cored and retained.

We proceeded with coring, now in harder formation, but soon were unable to advance because of bit failure at 14.3 mbsf. We tripped the tubing, unjayed the drill string, suspended the string in the derrick, set back the DCS platform, and tripped the DCS tubing for a bit change. Reversing that sequence, we resumed drilling.

With the second bit, we advanced through several highly vesicular basalt flows or pillows, with substantial recovery (64%) to 29 mbsf. Coring was fairly smooth and rapid.

Below this, however, we again encountered an unconsolidated formation, and here we faced the most significant weakness of the coring system. For nearly 50 m of subsequent penetration, we recovered virtually nothing. Two or three small chips of basalt would occasionally arrive on deck, but otherwise all we could discover about the formation was based on particles of sand twice found in returned core barrels, and once on the chiseled face of a bit deplugger. The sand suggests the presence of crystal-vitric tuffs, but the small particle size is probably a consequence of drilling. The rate of advance was rapid; at times there were abrupt drop-throughs of up to 1 m, possibly representing voids in the formation. For most of the interval, weight on bit was low and impossible to sustain for much distance. We reduced circulation to a bare minimum (at one point to nearly half the minimum recommended by the bit manufacturer) and devised traps to place in the plastic core liners in an attempt to recover anything at all. But no amount of coaxing could be used, no trick devised, to persuade material even to enter the core barrels. At one point, we lowered a center bit and, after drilling ahead for some meters, recovered it without so much as a scratch on its painted surface.

To the limited degree that we understand it, the problem is a combination of the design of the core catcher, the bit chosen for the coring, and the unconsolidated nature of the formation. First, the core catcher is designed to capture fractured but competent rock recovered at full-round core diameter. It has a wide throat. We had no expectation that unconsolidated breccias of such thickness would be at this location; thus we had no core catcher on board with fingers to capture gravel-sized or smaller rock fragments.

Second, we continuously pumped a viscous fluid combining seawater, weighted mud, and lubricant down the pipe while coring. The mixture passed through a narrow annulus at the base of the seated core barrel between it and the inner wall of the bit. The force of the spray was directed at the formation immediately ahead (1.5 cm) of the core barrel, evidently jetting the unconsolidated material away. That explains why not even the paint was removed from the center bit when it occupied the place of the core barrel.

Nonetheless, we eventually worked our way into more massive basalt flows once again, recovering a few fully cored pieces before the second bit expired at 79.2 mbsf. Probably, bit wear was accelerated or caused by a sand-blasting effect in the long interval of unconsolidated material we had just penetrated.

At this point, we set back the DCS platform and rigged for logging through the DCS tubing. The slim-line combined caliper and gamma tool made it down the tubing but did not pass an obstruction at the bit. The obstruction could not be cleared with the bit deplugger, so we retrieved the tubing to find 34 cm of basalt tightly wedged just above the throat of the bit. Sandy particles coated some of the rocks. Once again, we lowered the logging tool, this time through the drill pipe, but now we encountered another obstruction 2.3 m below the drill-in BHA. With the logging tool we worked it down to 13.7 mbsf, but no farther. As we no longer had the tubing string in place to drill out the obstruction, we elected to abandon the site after 1 month and 5 days of operations, leaving for Shatsky Rise (Site 810).

Site 810 (Shatsky Rise)

Approach to Site and Coring Operations

Shatsky Rise was approached from the southwest, and the ship passed over previously drilled DSDP Sites 306 and 305 in that order at 8 kt (Fig. 9) to link them to Site 810 with a continuous seismic reflection profile (Fig. 10). Steaming from south to north, we traced the principal chert horizon seismically to a point where the pelagic sediments capping it are only 0.07 s thick and dropped the beacon at 0600 hr on 22 July 1990. In order, we then recovered a single APC core for geriatric studies in Hole 810A, did a wash-in test to a sub-bottom depth of 60 m in Hole 810B to determine the length of conductor casing needed below the reentry cone, and continuously piston cored from a precisely located mud line to the uppermost substantial chert horizon at 125 mbsf in Hole 810C. One additional core was taken with the extended core barrel (XCB) in Hole 810C before we retrieved the drill pipe and lowered the reentry cone.

Attempts to Emplace a Reentry Cone

The principal difficulties with the reentry cone installation had to do with suspending casing in the casing hanger. Even before the reentry cone was lowered, one casing string was inadvertently dropped from the moonpool to the seafloor, evidently having become unthreaded while attempting to land the casing hanger. The hanger was removed and modified but then became wedged in the cone on a test and could not be removed. That meant that no casing could be suspended from it. We decided to lower the cone as it was, but added 14 drums of pig-iron ingots, plentifully abundant on board ship, to the skirt at the base of the cone in order to replace the weight the casing would have provided the assembly on the seafloor. This weight was required to tension the drill string properly during anticipated DCS coring operations.

After the cone was landed on the seafloor, we experienced repeated difficulties in trying to seat a drill-in bottom-hole assembly (DI-BHA). At first, it appeared that the back-off nut was not operating properly, but when the drill string was retrieved to inspect it, we found that the mechanism had landed properly but concluded that the key-slots which prevent the DI-BHA from unscrewing had failed, thus preventing back-off. We lowered the DI-BHA again, this time without tightening the back-off nut so that with only a small amount of frictional resistance it would unscrew. But once again the mechanism did not work, and the DI-BHA became stuck. After we freed it and retrieved the drill string, we found that a proper landing again had occurred but that the back-off nut had fused or jammed into its landing shoulder, possibly by means of the frictional heat produced by rotation, or loads imposed in varied seating attempts. That inadvertent "weld" managed to hold the entire 45,000-lb DI-BHA on its trip back to the ship.

We made one final attempt to land the DI-BHA, this time with a new beveled C-ring in the landing assembly. However, the bevel proved to be our undoing, since the landing shoulder was too narrow and simply compressed the C-ring on the bevel, allowing the entire DI-BHA to slip through the cone and drop into the soft ooze below. However, that appeared on deck to be a proper landing of the DI-BHA. The problem was discovered only when we could not get a sinker bar to the anticipated bottom of the DI-BHA in order to recover the center bit. When the drill string was retrieved, the back-off nut again was found to be fused or wedged into the landing sleeve. Back-off had actually occurred, but this time the entire DI-BHA had fallen out of the cone.

Rig-down, Fishing the DI-BHA, and Subsequent Survey

At this point, there was no time left for DCS coring. With the approach of inclement weather, the DCS tubing was taken from its vertical rack in the derrick and laid out in joints for storage on the riser hatch. There was still sufficient time to attempt to fish the DI-BHA. This was accomplished, and all drill collars were on deck by late afternoon on 29 July, 1990. All additional DCS hardware was then secured.

Since weather reports indicated that we still had as much as a day left before our departure would be mandatory, we proceeded to carry out a seismic survey of a portion of the summit of Shatsky Rise (Fig. 9). We cut the survey somewhat short at noon on 31 July, when the ship's barometer persuaded the Captain that we should leave the area with all possible speed.

SUMMARY OF ENGINEERING RESULTS AND ACCOMPLISHMENTS OF LEG 132

Site 809

Although it took a great deal longer than originally planned, all primary and specific engineering objectives for Site 809 were met. The difficulties with the HRB installation, the failure of the jay-tool, and the unforeseen complexities of configuring the secondary heave compensation system all contributed to delays in testing the DCS in coring operations and ultimately meant that one of the planned sites for the leg (M.I.T Guyot; proposed site ENG-7) had to be dropped, and that coring was severely curtailed at both Sites 809 and 810. There were also unsolved difficulties with core recovery. Nevertheless, the full DCS eventually was brought completely on-line, including the secondary heave compensation system, which operated well, keeping weight on bit to ±200-500 lb, depending on the sea state. The computer was also exceptionally reliable compared with the system used on Leg 124E, which was fraught with problems resulting from operating in the derrick under severe weather conditions.

In all, we penetrated the seafloor to a total of 79.2 m. The drill-in BHA was set in basement to 5.9 mbsf. Of the remaining 73.3 m, 50.9 m was cored and 14.3 m was drilled without coring, using the DCS. Recovery was fairly good (>60%) in fractured but competent rock. Several impressive cores were recovered, demonstrating the potential of the system. The DCS also managed to penetrate a thick, extremely incompetent and evidently very friable zone of rock without loss of hole stability, although the coring system was utterly incapable of retrieving this material. The fact that this material was penetrated without loss of hole stability is the consequence of the small-diameter (4-in.) hole, the low weight on bit, the precise cutting action of the narrow-kerf bit rotating at high speeds, and the continuous circulation of mud throughout coring operations. That compares with the torquing and pipe sticking experienced with conventional rotary coring right at the tops of exploratory Holes 809A and 809B.

The comparative success, however, must be weighed against the certainty that neither highly vesicular basalts nor thick vitroclastic breccias are known from the East Pacific Rise. Basalts there are considerably tougher and will be harder to drill. During the ten days of DCS operations at Site 809, only 3-1/2 days were actually spent in coring. There was not enough time to learn how to core basalts in a terrain that will be considerably more challenging to the DCS.

Operational efficiency and understanding of the system increased steadily each day, and toward the end of the site the SEDCO drill crew was handling most of the routine operations. The time required to perform such operations as tripping of tubing and drilling joints, strip-over operations, core-barrel handling, and turnaround, was cut nearly in half.

Additional experience was gained in using mud/coring motors for bare-rock spudding. In addition, we tested the new drill-in BHA system for the first time, demonstrating the importance and viability of casing off the upper parts of unstable holes. The experience gained will allow future multi-stage drill-in BHA systems to be developed which will provide stability in holes to even greater depths.

We learned a tremendous amount about how to place a hard-rock base on a locally complex seafloor. Relatively routine reentries into the open-ended casing hanger (≤ 24 in.)

will give rise to a much smaller reentry-cone design. That singular achievement, although accomplished under duress, will eventually result in a far superior, cheaper, and operationally more efficient seafloor guide-base design.

Last but not least, the techniques used in the recovery of the failed reentry cone, and the recovery and multiple placements of the HRB, demonstrate a considerable proficiency in the handling of heavy hardware at the end of a long drill string, using the dynamic positioning system of *JOIDES Resolution*. The capability, which was not previously appreciated, provides a new dimension to the scientific planning of drilling operations in difficult environments such as spreading ridges. The concept of "pogo" drilling is now fully proven. The capability of retrieving guide bases will also have important budgetary ramifications.

Hole 809F was the first successful bare-rock drilling/coring of basalt at an active submarine volcanic rift. The hole, although apparently bridged at the top, remains available for future drilling with a conventional rotary or an advanced diamond coring system.

Site 810

At Site 810 we confirmed that chert cannot be piston cored, nor can undisturbed sediments be sampled between chert layers with the extended core barrel. Probably the material would have been extremely difficult to recover by DCS coring with the open-throat core catchers we had on board. The problem very clearly is how to recover extremely hard rock (chert) embedded in buttery ooze. Such a sequence is probably unique to the marine environment; nothing comparable has been attempted with diamond coring on land. Before attempting to core in such material again, serious thought has to be directed toward how to go about recovering the material.

Finally, we discovered problems with the design and construction of the landing structure used for seating casing or a drill-in bottom-hole assembly in the modified reentry cone. We successfully fished one such DI-BHA after it had fallen completely through the reentry cone, and had dropped some 25 m into soft oozes beneath it. The reentry cone is still on the seafloor for future DCS coring.

CONCLUSIONS

Leg 132 may seem to have been one long series of trials and difficulties, and, to a degree, it was. However, as an engineering leg, it accomplished what it set out to do. Every single component of the DCS and both seafloor installations were evaluated at sea. Although we managed far less coring time than was desired with the DCS, that system now is fully functional. So, too, after a difficult period of evaluation, is the dual heave-compensation system. Even the difficulties with the hard-rock base were eventually overcome, the effectiveness of the drill-in bottom-hole assembly was demonstrated, and only lack of time prevented emplacement of the drill-in bottom-hole assembly at Site 810.

Two components of the integrated system need some redesign and more attention to construction: the seafloor installations and the core-recovery system. However, in both cases, the modifications that will ensure future success are obvious. The hard-rock base probably should be mounted on three legs rather than four, the gimbaled reentry cone should be counterweighted rather than held upright by flotation, and devices should be installed to assess guide-base orientation on the seafloor before separation from the drill string. Variations in leg length and size of pad may allow installation of the HRB in steeper, rougher terrain. The J-tool needs more robust construction. A more uniform lighting system for the TV camera needs to be added to the VIT frame, and a stereographic camera system should be added to return high-quality still photographs of the HRB and surrounding seafloor to the ship.

For future coring, there needs to be much more flexibility in core-barrel assemblies, particularly in the design of core catchers. A means must be devised to prevent circulating fluids from eroding unconsolidated sediments and breccias before they can enter the core barrel. An adaptation of the advanced piston corer to the DCS, but one that would penetrate soft sediments very slowly, may be the only way to capture buttery nannofossil ooze between chert layers.

REFERENCES

Cann, J.R., Luyendyk, B.P., et al., 1979. *Init. Repts. DSDP,* 49: Washington (U.S. Govt. Printing Office).

Detrick, R., Honnorez, J., Bryan, W.B., Juteau, T., et al., 1988. *Proc. Ocean Drilling Program, Initial Repts.(Pt. A),* 106/109: College Station, TX (Ocean Drilling Program).

Harding, B., Storms, M., et al., 1990. *Proc. Ocean Drilling Program, Initial Repts.,* 124E:

Natland, J.H., and Rosendahl, B.R., 1980. Drilling difficulties in basement during Deep Sea Drilling Project Leg 54. *In* Rosendahl, B.R., Hekinian, R., *Init. Repts. DSDP,* 54: Washington (U.S. Govt. Printing Office), 593-603.

Taira, A., Hill, I.A. et al., in press. *Proc. ODP, Init. Repts.,* 131: College Station, TX

Taylor, B., Brown, G., Fryer, P., Gill, J., Hochstaedter, F., et al., in press. *Alvin* -SeaBeam studies of the Sumisu Rift, Izu-Bonin area. *Earth Planet. Sci. Lett.*

Yeats, R., Hart, S., and the Leg 34 Scientific Party., 1976. Preliminary evaluation of DSDP coring experience in basalt. *In* Yeats, R., Hart, S., et al., *Init. Repts. DSDP,* 34: Washington (U.S. Govt. Printing Office), 183-186.

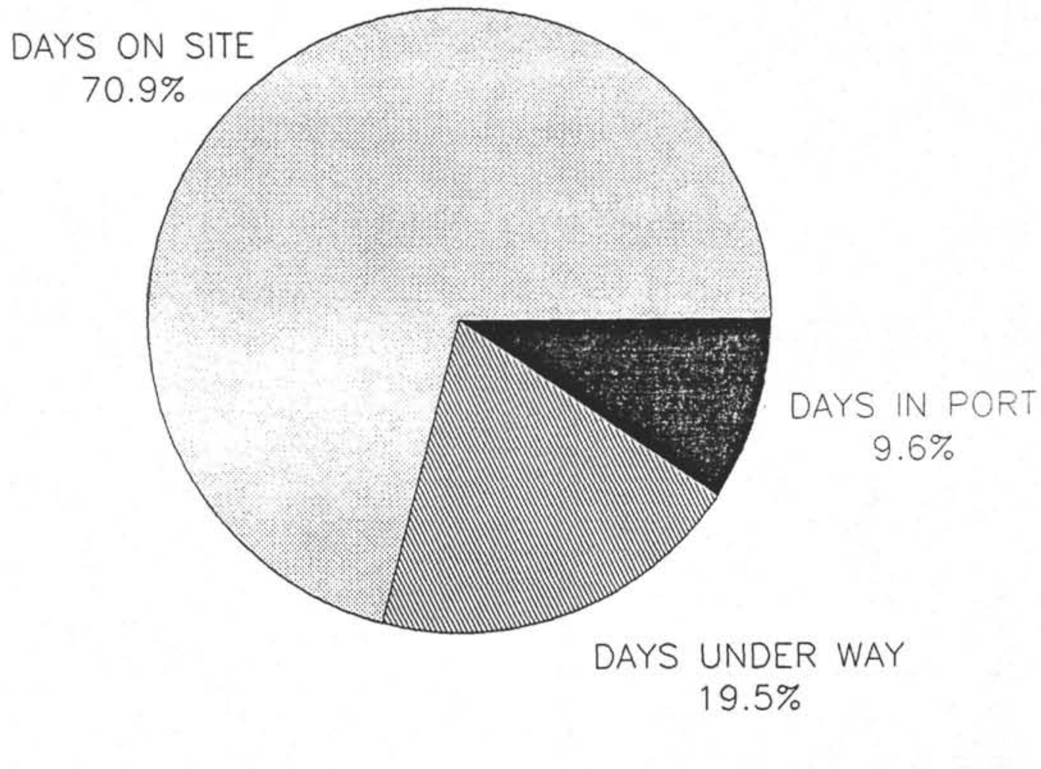
OCEAN DRILLING PROGRAM
OPERATIONS RESUME
LEG 132

Total Days (6/2/90 - 8/4/90)	63.5
Total Days in Port	6.1
Total Days Under Way	12.4
Total Days on Site	45.0

Trip Time	12.3
Coring Time	.3
Drilling Time	1.7
Logging/Downhole Science Time	1.4
Reentry Time	2.6
Repair Time (Contractor)	.2
Fishing	1.1
Other	3.4
Development Engineering Time	22.0

Total Distance Traveled (nautical miles)	3252
Average Speed (knots)	10.9
Number of Sites	3
Number of Holes	11
Number of Reentries	28
Total Interval Cored (m)	204.6
Total Core Recovery (m)	164.7
Percent Core Recovered	80.5
Total Interval Drilled (m)	120.3
Total Penetration (m)	324.9
Maximum Penetration (m)	136.1
Maximum Water Depth (m from drilling datum)	4682.4
Minimum Water Depth (m from drilling datum)	1799.6

LEG 132
TOTAL TIME DISTRIBUTION



TOTAL DAYS OF LEG = 63.5

SCIENTIFIC REPORT

The scientific party aboard *JOIDES Resolution* for Leg 132 of the Ocean Drilling Program consisted of:

James H. Natland, Chief Scientist (Scripps Institution of Oceanography, La Jolla, California 92093)
Garrett W. Brass (Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149-1098)
Glenn R. Brown (Scotiabank Marine Geology Research Laboratory, University of Toronto, 22 Russell Street, Toronto, Ontario M5S 1A1, Canada)
Isabella Premoli-Silva (Department of Earth Sciences, University of Milano, via Mangiagalli, 34, Milano 20133, Italy)
Frank Rack (Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, Texas 77845-9547)
William V. Sliter (U.S. Geological Survey, Branch of Paleontology, M/S 915, 345 Middlefield Road, Menlo Park, California 94025)
Robert J. Van Waasbergen (Scripps Institution of Oceanography, La Jolla, California 92093)

SCIENTIFIC OBJECTIVES OF LEG 132

The scientific objectives of Leg 132 were closely related to the development and successful use of the diamond coring system (DCS). The DCS was designed to improve both coring and recovery of rock. Leg 132 was intended to test the DCS in two previously difficult drilling environments where it was expected to provide materials of sufficient coherence and continuity to aid in understanding detailed relationships of lithology, stratigraphy, sedimentary diagenesis, and igneous alteration.

Although only a short section was cored with the DCS at the first site (Site 809), and it was not possible to use it at the other (Site 810), the results bear considerably on plans for drilling in similar environments elsewhere. The two environments were (1) fractured, uncemented pillow basalts in axial, hydrothermally active regions of spreading ridges; and (2) Mesozoic sequences of layered chert-porcellanite and chalk with alternating hard and soft characteristics. Originally, a third environment of reef-lagoonal deposits with contrasting coarse (loose) and fine-grained (firm) characteristics was planned for DCS drilling. That target was deleted during the leg when it became clear that the first (and foremost) objective, on unsedimented igneous rock, required considerably more time than was originally anticipated.

Previous experience with conventional rotary coring in chert/chalk sequences (as well as reefal limestones) is that, although drilling can proceed, recovery is typically too poor, particularly in the soft or coarse intervals, to provide either biostratigraphic control or sufficient material for the study of pore fluids and the mechanisms of diagenesis. Critical intervals (such black shales, which are believed to exist, based on Aptian/Albian exposures on land), have apparently been missed in several of the Mesozoic chert/chalk sequences cored in the Pacific to date.

In pillow basalts at young ridges, coring results have been even worse. The drilling literature concerned with that is replete with accounts of torn-up core bits, blown-off bottom-hole assemblies, low (or no) recovery , and endlessly foiled attempts to drill holes more than a few tens of meters deep. Coring such basalts has long been a major concern of scientists interested in crustal drilling and was an important motivation in the development of the DCS. The results of the drilling on Leg 132 were to determine the feasibility of two drilling legs planned for the East Pacific Rise in 1991-92.

In terms of the immediate drilling targets of Leg 132, two scientific objectives can be summarized very simply. First, to make hole; to develop a system which will core in fractured rock without problems of hole stability. Second, more is better, specifically, to obtain more recovery. It is impossible to judge lithologic relationships meaningfully, understand processes of sedimentary diagenesis or crustal alteration, relate cores to logging results, or obtain a sensible magnetic stratigraphy without acquisition of fully cored, oriented rock samples. In basalts, fragile breccias and hydrothermal deposits are almost completely destroyed in the process of rotary coring. In chert/chalk sequences, almost all the chalk and perhaps much of the chert is ground to paste and washed out rather than recovered in the core barrel.

The spreading-ridge target drilled at Site 809 is about 1 km from the topographic axial high of a small volcanic ridge on the Sumisu Rift, a backarc basin west of the Bonin volcanic island arc (Fig. 8). Submersible results previously established that the terrain is primarily pillow basalts only thinly dusted by sediments (Taylor et al., in press). Basalts obtained during dive operations and by dredging include fairly typical backarc-basin basalts, despite the close proximity of the arc, and some rhyodacites (Hochstaedter et al., in press; Fryer et al., in press). Previous drilling during ODP Leg 126 recovered both backarc and arc-like basaltic basement rocks beneath thick sediments a few kilometers to the south at Sites 709 and 710 (Taylor, Fujioka, et al., 1990). We expected to recover coherent cored sections of basaltic pillows and flows to augment those studies.

The scientific objective at Site 810 was to drill a bedded chert/chalk sequence of Aptian-Albian age unconformable beneath a cap of largely eroded Paleogene-Neogene chalks and oozes about 125 m thick exposed on a flank of Shatsky Rise (Fig. 9). Previous drilling on DSDP Legs 6, 32, and 86 (Fischer, Heezen, et al., 1971; Larson, Moberly, et al., 1975; Heath, Burckle, et al., 1985) recovered primarily broken chert/porcellanite fragments in materials of this age from Shatsky Rise. The sedimentary rocks are of interest because they were deposited in moderate depths atop a volcanic plateau that probably formed at a hot-spot triple-junction intersection (Nakanishi, Tamaki, and Kobayashi, 1989). The sediments presumably preserve both siliceous and calcareous microfossil assemblages that were not all preserved in deeper waters at these times. Moreover, coring elsewhere in the Pacific, together with observations in Franciscan exposures in California (Sliter, 1989) suggests that the intervals of high silica productivity recorded by the cherts were associated with or punctuated by intervals of anoxia, which may have been widespread at certain levels in the water column during the Cretaceous. Although scattered organic-rich sediments deposited at these times have been recovered by drilling in the Pacific, understanding them requires the precise multifaunal biostratigraphic control that only near continuous recovery can provide.

Two final scientific objectives were to test a slim-line combined gamma-caliper logging tool in a 4-in. diameter DCS hole, and to acquire several cores of sediment for a geriatric study to monitor long-term changes to cores from the time they are first brought on deck through long intervals of storage on board ship and in the shorebased repositories.

SITE 809

Operational Summary

At Site 809, an optimum "bare-rock" site location was selected following a beacon drop during an underwater television survey. Two pilot holes (809A and 809B) were spudded and drilled using a conventional 9-1/2-in. positive-displacement coring motor (PDCM) and two different-sized bits (11-5/8 and 9-7/8 in.). These holes established the degree of uppermost formation stability and determined the number of drill collars to be drilled in at the HRB location. The vicinity of Hole 809B was selected for placement of the HRB. This hole also provided information necessary for proper location of the back-off sub in the drill-in BHA. The pilot holes were drilled with special DCS bit/center-bit assemblies, and no cores were taken.

After completion of a drill-pipe round trip, the HRB was deployed and landed at the seafloor. The planned sequence was as follows: Another drill-pipe round trip was to be made to make-up the drill-in BHA and back-off sub hardware. The assembly was to be reentered into the HRB and drilled with the PDCM to the appropriate depth. After landing and latching the lower portion of the BHA in the HRB, it was then to be released using the back-off sub. The released collars were to provide the casing required for deploying and coring ahead with the DCS system.

Although Hole 809C was expected to utilize these same techniques, a variety of complications ensued requiring moving of the HRB three times before a BHA was finally emplaced 5.9 m into basalt. At Hole 809F, with the DCS, 73.3 m were ultimately cored and drilled beyond the BHA in a fractured, unsedimented, crystalline-rock environment.

Science Summary

In Hole 809F, three chemically distinct basalt types were encountered in the 73.3 m of igneous formation penetrated by the diamond coring system below the casing shoe at 5.9 mbsf. Successively these are (1) fairly strongly fractionated ferrobasalt (Mg# = 0.43) from 5.9 to 21 mbsf; (2) moderately fractionated olivine tholeiite (Mg# = 0. 60) from 21 to 29 mbsf, just above the 50-m interval with very low recovery; and (3) another moderately fractionated olivine tholeiite (Mg# = 0.60) from just below this interval in the last core obtained, between 78.9 and 79.2 mbsf.

The basalts are all extremely sparsely phyric, highly vesicular tholeiites similar to basalts dredged, drilled, and sampled by submersible from this incipient backarc rift. They are pillows or thin flows with glassy exteriors and more crystalline interiors. All the rocks are extremely fresh, with only minor oxidative alteration evident near some fractures. Most vesicles are partially lined with unaltered glass; only a few are lined with pale green clays or iron oxyhydroxides. The vesicles are a prominent feature of these basalts. All the rocks contain myriad irregular to round pinhole vesicles, but there are some very large vesicles (to 1-cm diameter) especially in the more evolved upper ferrobasalt. In this basalt, some of the larger vesicles are arrayed in trains across the rock face within pillow or flow interiors. Many of the larger vesicles are segregation vesicles, being partly filled with frozen melt, itself vesicular, which leaked into them as their walls ruptured during crystallization of the rock. One rock contains a fracture into which melt also leaked, annealing it completely. There is a good correlation between physical properties (velocity, density) and vesicle distribution in the basalts.

The basalts are glassy to spherulitic near quench margins, and more crystalline in the pillow/flow interiors. The less fractionated basalts carry minor olivine (no spinel) and have less abundant titanomagnetite than the ferrobasalt. There are a few rare plagioclase phenocrysts. Apart from the olivine, the crystallization sequence in all the basalts was the same: co-precipitating plagioclase and clinopyroxene were followed in intergranular spaces by spectacularly skeletal titanomagnetite and rare, tiny rods of ilmenite. Even tinier pyrrhotite spherules decorate the rims of the oxide minerals, thus segregated only during the very final stages of crystallization of the basalts.

The uppermost ferrobasalt and immediately underlying olivine tholeiite have the typical elevated K_2O (0.60 and 0.32%, respectively), Rb (10 and 5 ppm), and Ba (61 and 45 ppm) abundances, and the relatively low TiO_2 (1.7% at Mg# = 0.43; 1.2% at Mg# = 0.60), Zr (72 and 56 ppm) and Y (27 and 19 ppm) of many backarc-basin basalts. They are virtually identical to basalts previously sampled from this volcanic ridge. The lowermost basalt, obtained below the 50-m interval with virtually no recovery, is similar in most respects to the olivine basalt above the interval of low recovery, but it has somewhat lower

K_2O (0.29%) and much lower Ba (19 ppm) contents. Thus, it resembles basalts from Site 791 drilled during Leg 126, which are interpreted to represent syn-rift basalts dating from the early stages of the opening of the Sumisu rift (Fujioka, Taylor, et al., 1989).

We speculate that the interval of very low recovery represents highly vesicular and expanded basaltic glass similar to the basalt "mousse" recovered at Site 791. The rock compositions and stratigraphy suggest that we cored through a thin carapace of backarc basalts into syn-rift volcanic rocks deposited on subsided pre-rift basement, which projects on seismic profiler records to a shallow elevation at this location.

SITE 810

Operational Summary

Operations at Site 810 (Shatsky Rise) differed from the bare-rock deployment at Site 809 because there is 125 m of soft carbonate ooze overlying chert/chalk beds at this location, which required a modified reentry cone rather than a hard-rock base through which DCS coring was to take place. The sediments were to provide skin friction against a BHA hung from the reentry cone against which the outer drill string, latched into the cone, could be tensioned. Unfortunately, for a variety of operational and meteorological reasons, the reentry cone was never fully emplaced on the seafloor, and DCS operations were never attempted before departing for Guam.

Nevertheless, at Hole 810C, much information about the modified reentry cone was obtained. A 125-m section (erosionally shortened) of nannofossil ooze and clayey ooze ranging in age from Late Cretaceous (Maestrichtian) through the Cenozoic was continuously cored. The sediments were cored with the advanced piston corer (APC) and thus were largely undisturbed on recovery. An additional core was obtained by APC in a separate hole (Hole 810A) to evaluate long-term geriatric changes in sediments through time, a study sponsored by the Curator of the Ocean Drilling Program.

Science Summary

At Site 810, Holes A and C, we recovered a cumulative total of 153.6 m of Cenozoic and Upper Cretaceous nannofossil ooze (Fig. 11). The shortened section records hiatuses in the upper Miocene/lower Eocene; lower Eocene/upper-lower Paleocene; and lower Paleocene/upper Maestrichtian. The oldest sediment recovered was early Maestrichtian. A complete Cretaceous/Tertiary boundary sequence was not present. The hiatuses represent intervals of erosion and redeposition in this shortened section. Many of the sediments contain reworked foraminiferal assemblages and show structural evidence for the action of currents. Five lithologic units are distinguished as follows:

Unit I (0-4.2 mbsf). Pleistocene brown to dark gray nannofossil ooze with cut-and-fill structures and evidence for mixing of cooler and warmer water faunas.

Unit II (4.2-76.0 mbsf). Lower Pliocene to Pleistocene light gray to white nannofossil ooze, characterized by evidence for increasing dissolution and mixing downsection. The unit contains a number of thin ash beds and one quite thick (14 cm) ash bed and rounded pumiceous dropstones derived from arc systems to the west.

Unit III (76.0-99.5 mbsf). Upper(?) Miocene to lower Pliocene pale tan to tan clayey nannofossil ooze and calcareous clay, with rhythmic color alternations corresponding to varying clay contents (highest estimated 70%). Foraminiferal assemblages show evidence for strong dissolution. The base of the unit is at a hiatus.

Unit IV (99.5-113.3 mbsf). Upper Paleocene and lower Eocene pale tan nannofossil ooze, separated from the overlying Unit III by a hiatus. Paleocene foraminiferal assemblages are strongly reworked and include some Cretaceous forms. There is evidence for slumping and size sorting.

Unit V (113.3-136.1 mbsf). Upper Cretaceous to upper Paleocene white nannofossil ooze with large coccolith plates and small chert nodules. The pale color and coring deformation in the lower 10 m make identification of structures difficult, but there is a hiatus across the Cretaceous/Tertiary boundary.

We obtained an excellent array of measurements for physical properties and magnetic susceptibility, which show strong correlations with cyclical lithologic variations in the sediments. Although the section is broken by hiatuses, the upper two lithologic units carry detailed information relating to the development of eolian transport from the Asian mainland during the climatic deterioration that occurred between the Pliocene and Pleistocene.

REFERENCES

Fischer, A.G., Heezen, B.C., et al., 1971. *Init. Repts. DSDP,* 6: Washington (U.S. Govt. Printing Office).

Fryer, P., Langmuir, C.H., Hochstaedter, A.G., and Taylor, B., in press. Petrology and geochemistry of igneous dredge samples from the Sumisu backarc rifts. *Earth Planet. Sci. Lett.*

Fujioka, K., Taylor, B., et al., 1989. Arc volcanism and rifting. *Nature* , 342:18-20.

Heath, G.R., Burckle, L., et al., 1985. *Init.Repts. DSDP,* 86: Washington (U.S. Govt. Printing Office).

Hochstaedter, A.G., Gill, J.B., Langmuir, C.H., Morris, J.D., and Pringle, M., in press. Petrology and geochemistry of lavas from the Sumisu Rift: an incipient back-arc basin. *Earth Planet. Sci. Lett.*

Larson, R., Moberly, R., et al., 1975. *Init. Repts. DSDP,* 32: Washington (U.S. Govt. Printing Office).

Nakanishi, M., Tamaki, K., and Kobayashi, L., 1989. Mesozoic magnetic anomaly lineations and seafloor spreading history of the Northwestern Pacific. *J. Geophys. Res.*, 94:15437-15462.

Sliter, W., 1989. Aptian anoxia in the Pacific basin. *Geology,* 17:909-912.

Taylor, B., Brown, G., Fryer, P., Gill, J., Hochstaedter, F., et al., in press. *Alvin* -SeaBeam studies of the Sumisu Rift, Izu-Bonin area. *Earth Planet. Sci. Lett.*

Taylor, B., Fujioka, K., et al., 1990. *Proc. ODP, Init. Repts.*, 126: College Station, TX (Ocean Drilling Program).

TABLE CAPTIONS

Table 1. ODP Leg 132 Operational Site Summary

FIGURE CAPTIONS

Figure 1. Schematic diagram of the diamond coring system in place in the derrick of *JOIDES Resolution,* and one of the two types of seafloor installations.

Figure 2. Platform configuration of the diamond coring system.

Figure 3. Schematic cross section of the weighted hard-rock base (mini guide base) in place on sloping sea floor.

Figure 4. Schematic cross section of the modified reentry cone in place on sediments above a hard-rock surface on the seafloor.

Figure 5. Drawing showing the relationship of the drill pipe, tensioning tool and landing seats to the casing hanger and optional hard-rock base or reentry cone on the seafloor.

Figure 6. Schematic diagram of the drill-in bottom-hole assembly (DI-BHA).

Figure 7. Cruise track in the western Pacific of *JOIDES Resolution* during Leg 132.

Figure 8. Bathymetry of Central Ridge in the Sumisu Rift, after Hochstaedter et al. (in press) showing the location of Site 809. The contour interval is 50 m. Shaded above 1800 m.

Figure 9. Bathymetry of a part of Shatsky Rise (200-m contours) showing the location of DSDP sites and ODP Site 810. The incoming seismic line linking DSDP Sites 305 and 306 with Site 810 (Fig. 10) is shown as a solid line. The track of a post-site seismic survey is shown by the dashed line.

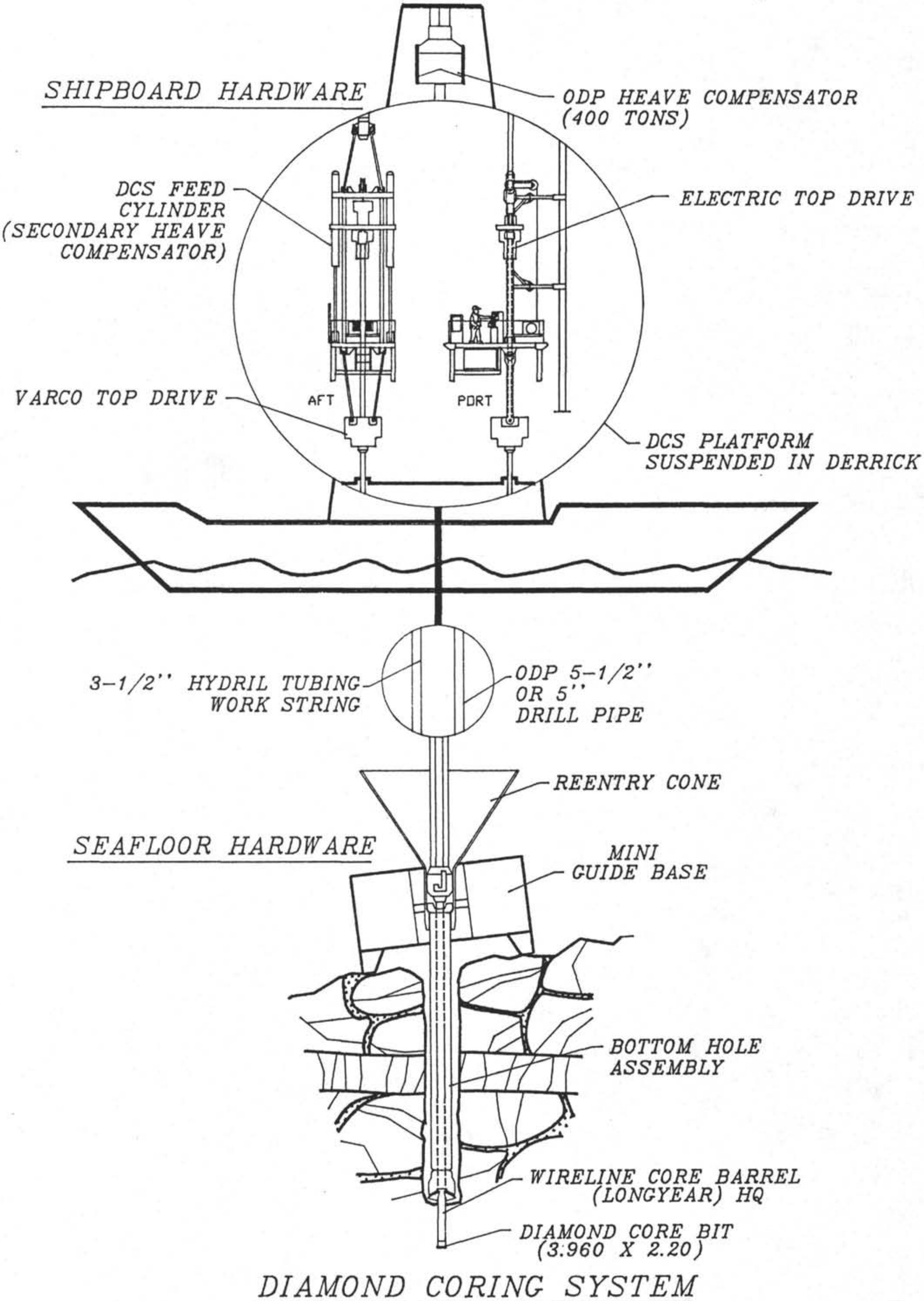
Figure 10. *JOIDES Resolution* seismic profiler record obtained during the approach to Site 810 on Shatsky Rise. The arrow indicates the principal seismic reflector (chert horizon) traced beneath the pelagic sediment cap.

Figure 11. Summary lithologic column for sediments recovered from Hole 810C during Leg 132. Sediment ages, foraminiferal zones, and character of foraminiferal fauna are also shown.

OCEAN DRILLING PROGRAM
SITE SUMMARY REPORT
LEG 132

HOLE	LATITUDE	LONGITUDE	SEA FLOOR DEPTH (M)	NUMBER OF CORES	INTERVAL CORED (M)	RECOVERED CORE (M)	PERCENT RECOVERED	INTERVAL DRILLED (M)	TOTAL PENETRATION (M)	TIME (HRS)
809A	31-03.44N	139-52.72E	1819.7	0	.0	.0	.0	8.3	8.3	30.25
809B	31-03.48N	139-52.66E	1799.6	0	.0	.0	.0	13.4	13.4	21.00
809C	31-03.50N	139-52.63E	1801.5	0	.0	.0	.0	4.1	4.1	209.75
809D	31-03.49N	139-52.67E	1802.0	0	.0	.0	.0	6.3	6.3	82.75
809E	31-03.51N	139-52.64E	1803.0	0	.0	.0	.0	8.0	8.0	33.25
809F	31-03.50N	139-52.64E	1802.5	33	59.0	11.1	18.8	20.2	79.2	471.00
	SITE TOTALS:			33	59.0	11.1	18.8	60.3	119.3	848.00
810A	32-25.37N	157-50.75E	2633.0	1	9.5	9.8	103.2	.0	9.5	8.25
810B	32-25.37N	157-50.75E	2633.0	0	.0	.0	.0	60.0	60.0	2.50
810C	32-25.40N	157-50.74E	2634.1	16	136.1	143.8	105.7	.0	136.1	19.25
810D	32-25.36N	157-50.73E	2634.1	0	.0	.0	.0	.0	.0	146.50
	SITE TOTALS:			17	145.6	153.6	105.5	60.0	205.6	176.50
808E	32-21.09N	134-56.60E	4682.4	0	.0	.0	.0	.0	.0	56.00
	SITE TOTALS:			0	.0	.0	.0	.0	.0	56.00
	LEG TOTALS:			50	204.6	164.7	80.5	120.3	324.9	1080.50

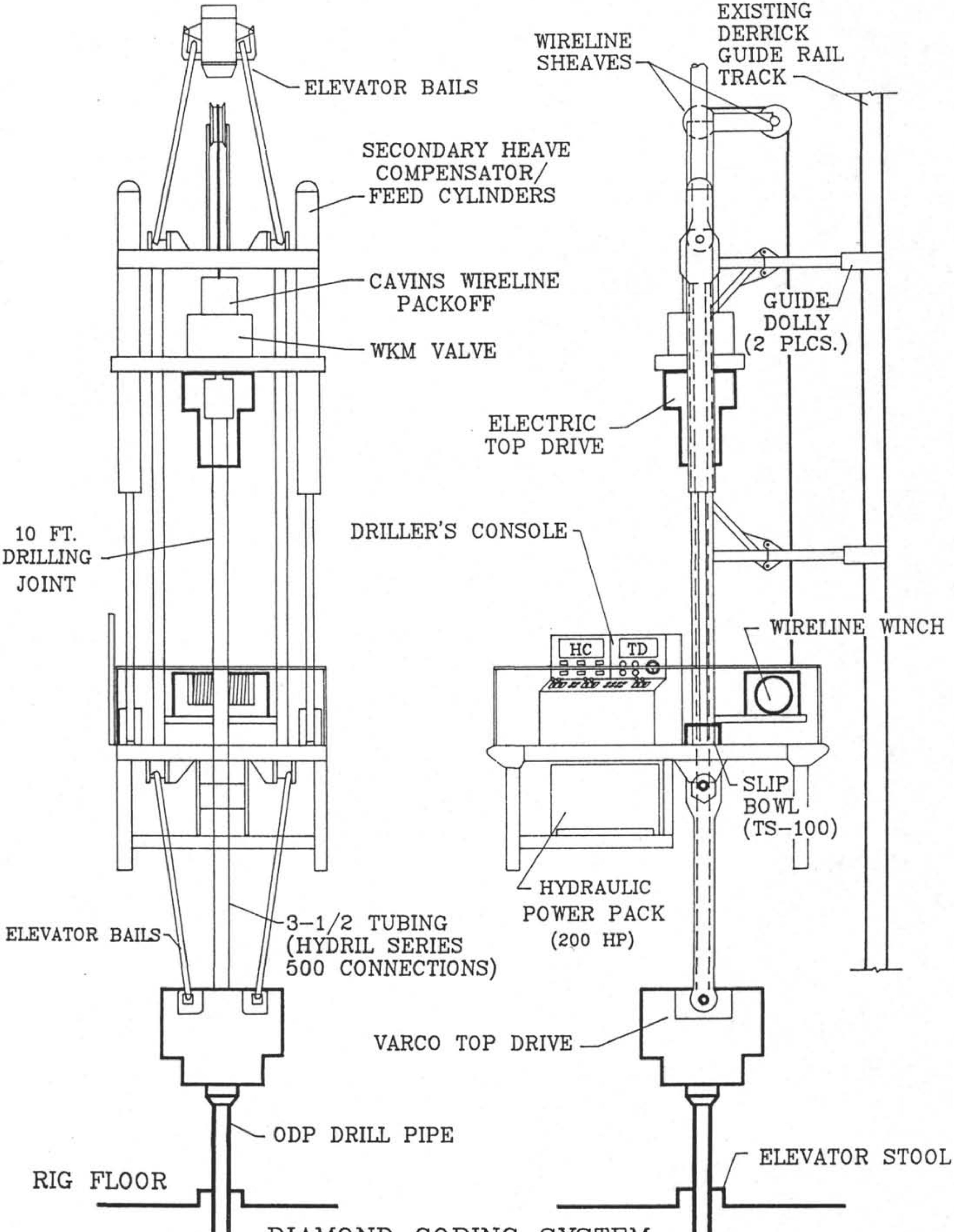
Table 1



DIAMOND CORING SYSTEM

PHASE II - 4500 METER

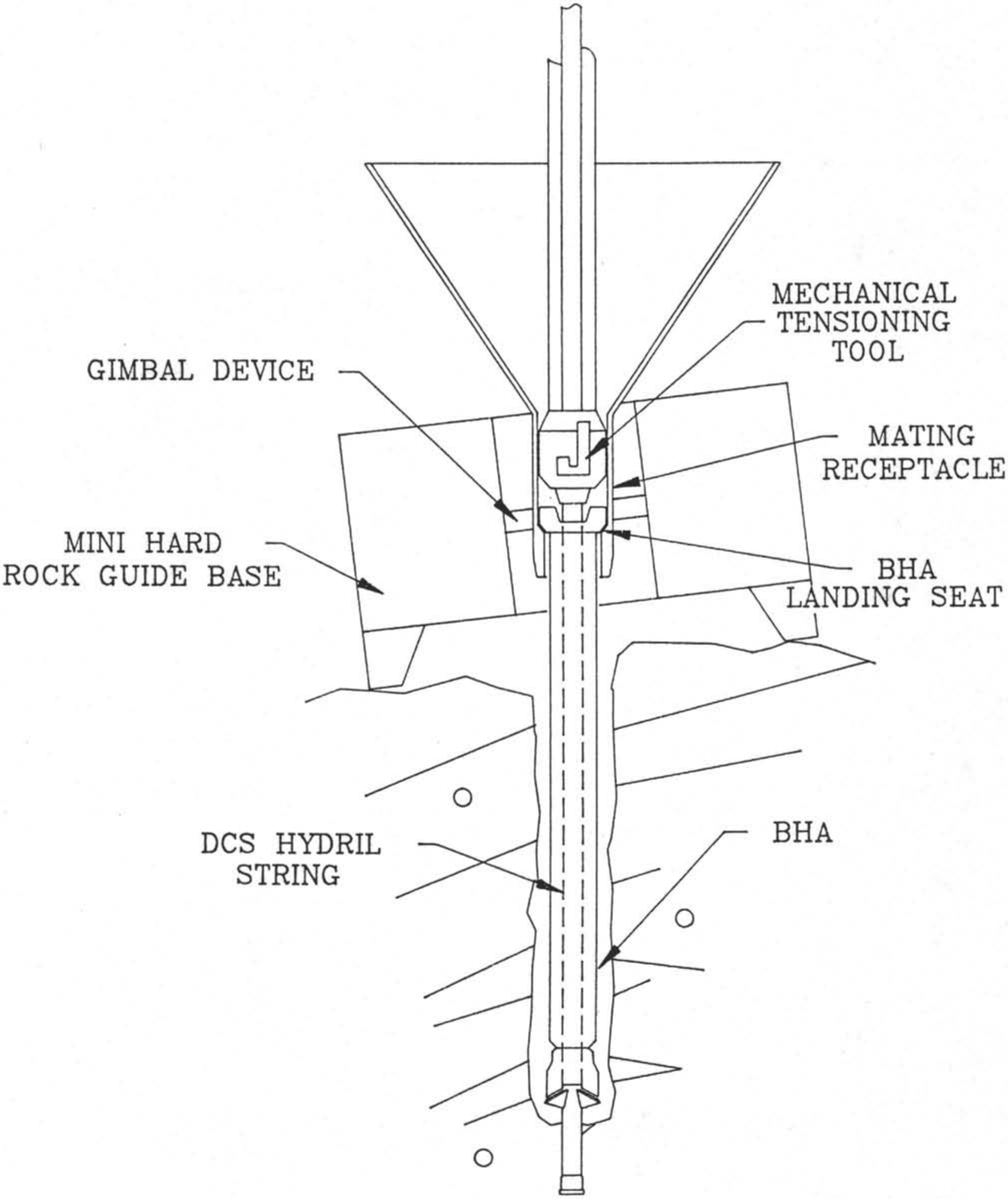
Figure 1



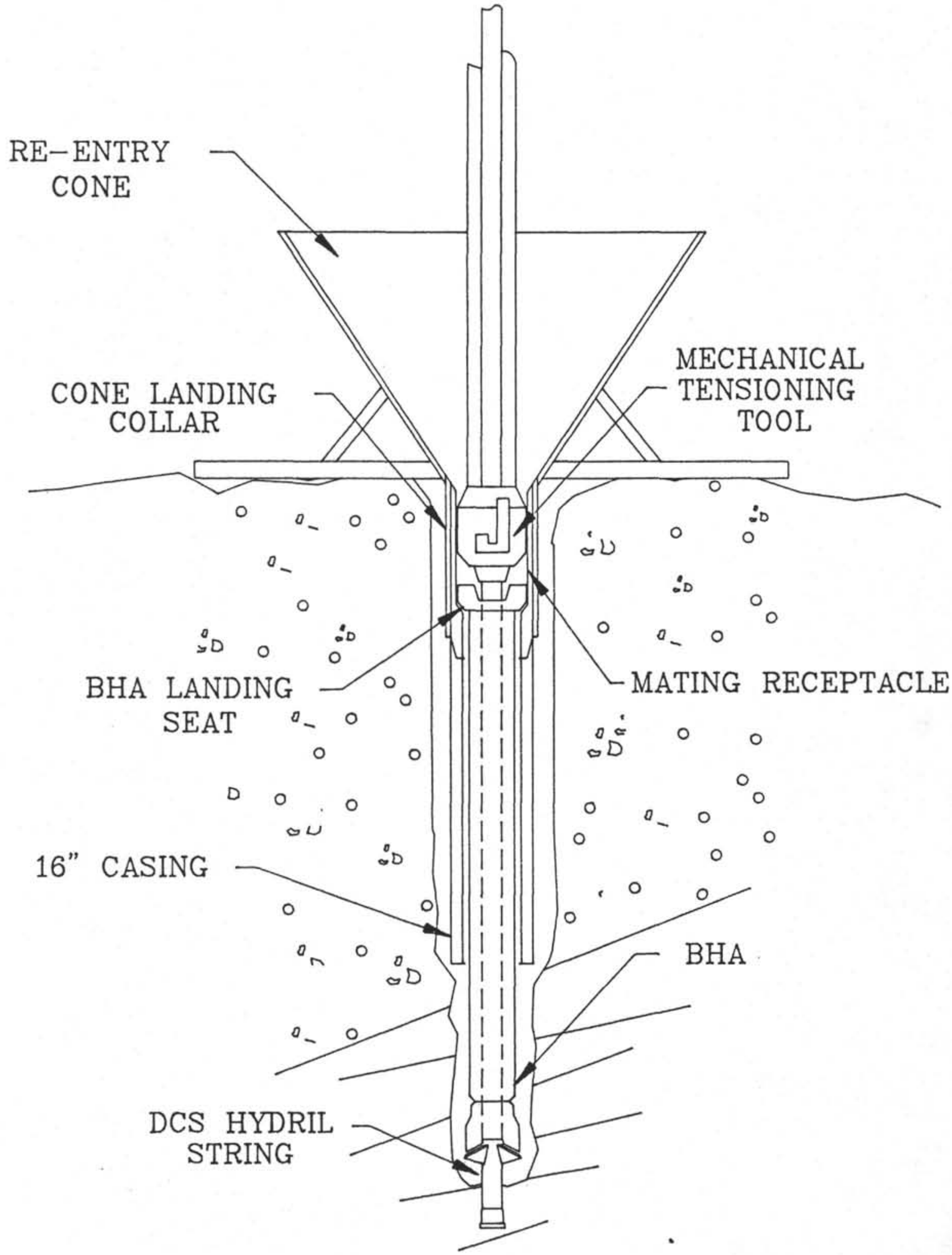
DIAMOND CORING SYSTEM PLATFORM CONFIGURATION

PHASE II - 4500 METER DEPTH CAPACITY

Figure 2

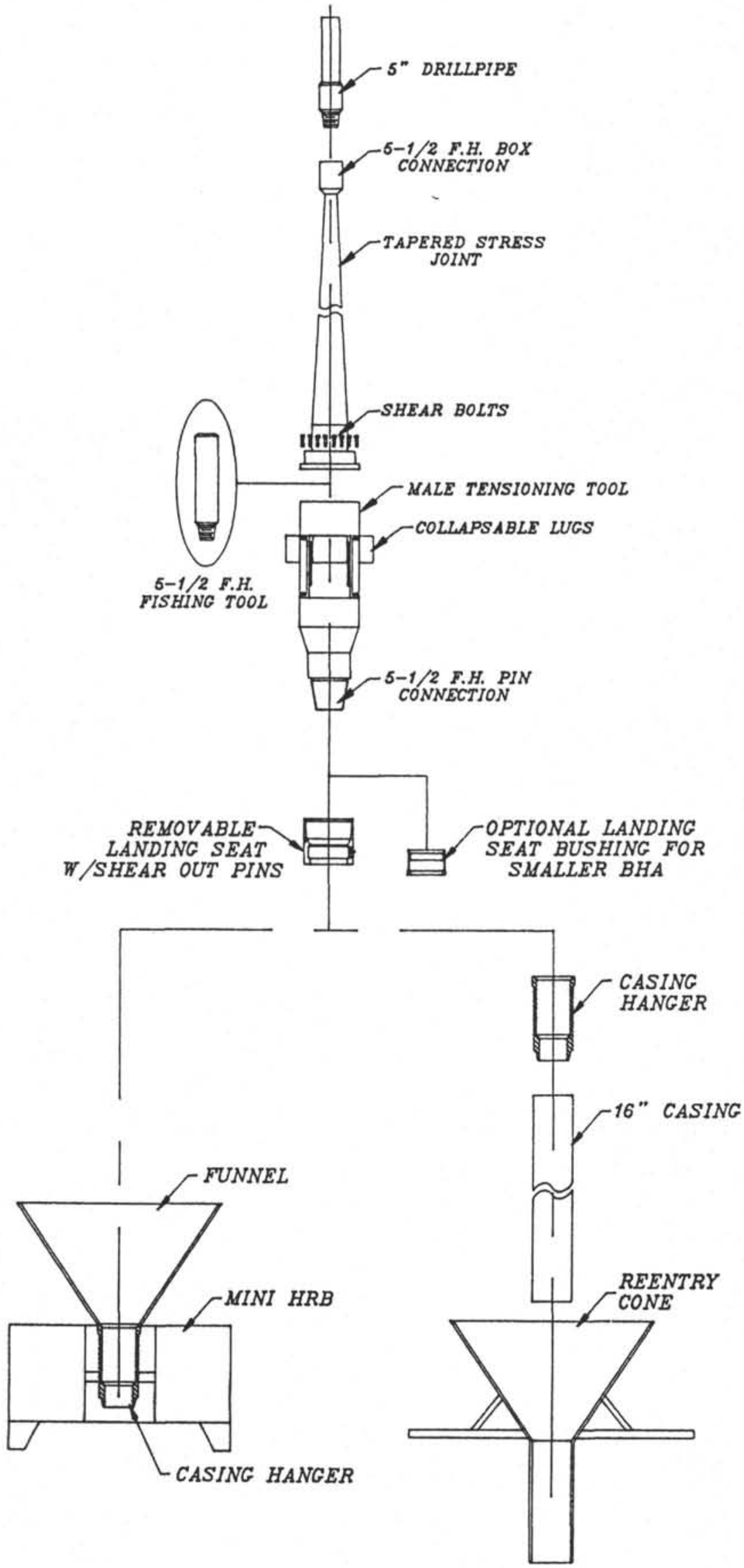


WEIGHTED MINI GUIDE BASE FOR BARE ROCK OPERATIONS
USING BACKED OFF BHA FOR UPPER HOLE STABILIZATION
Figure 3



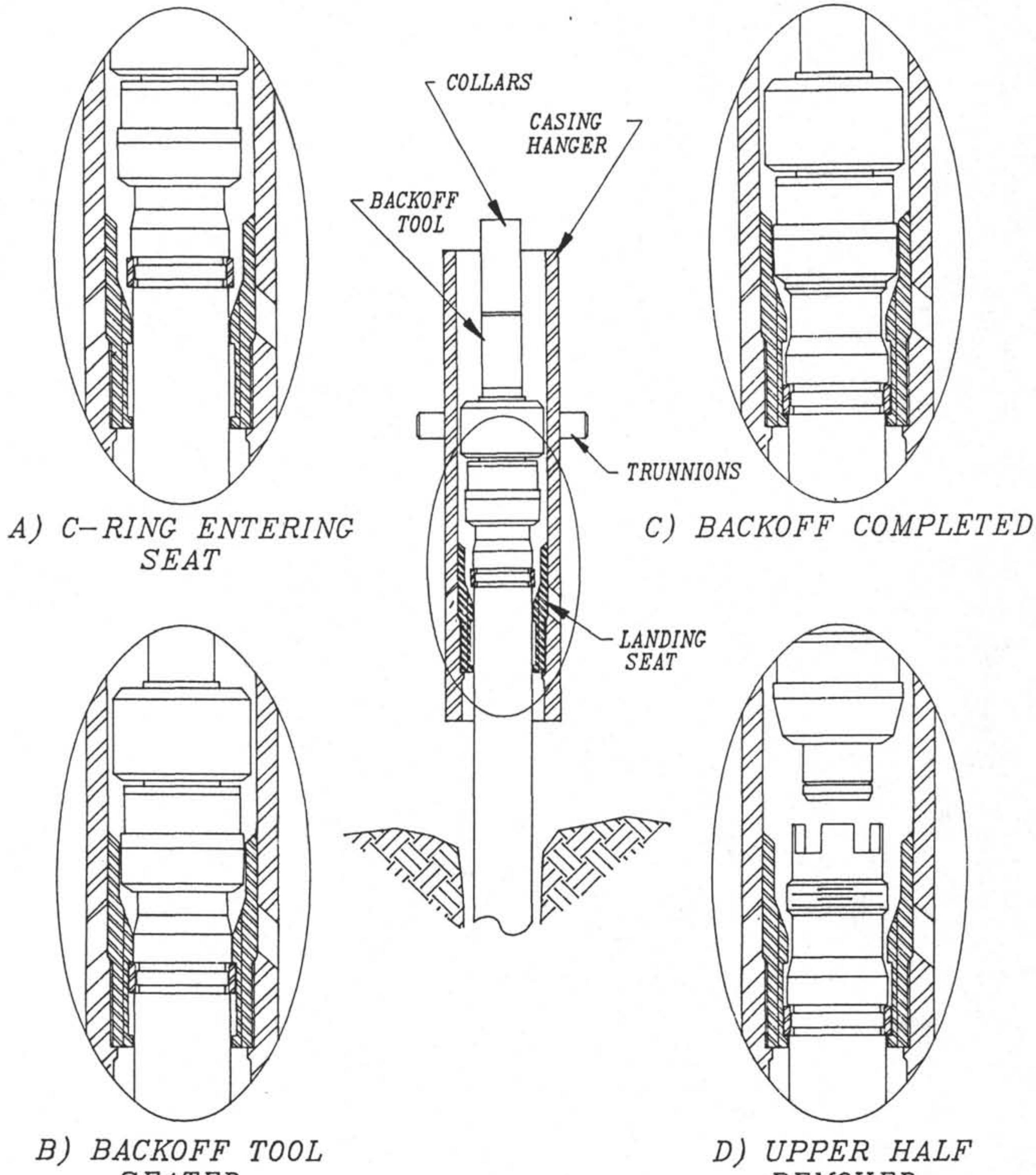
RE-ENTRY CONE WITH CASING
FOR SEDIMENT OVERLAYING HARD ROCK
USING BACKED OFF BHA FOR UPPER HOLE STABILIZATION

Figure 4



SEAFLOOR HARDWARE OPTIONS

Figure 5



DEPLOYMENT SCHEME FOR BACK-OFF SUB

NOTE: GUIDE BASE NOT SHOWN FOR CLARITY

Figure 6

Leg 132 Drill Sites

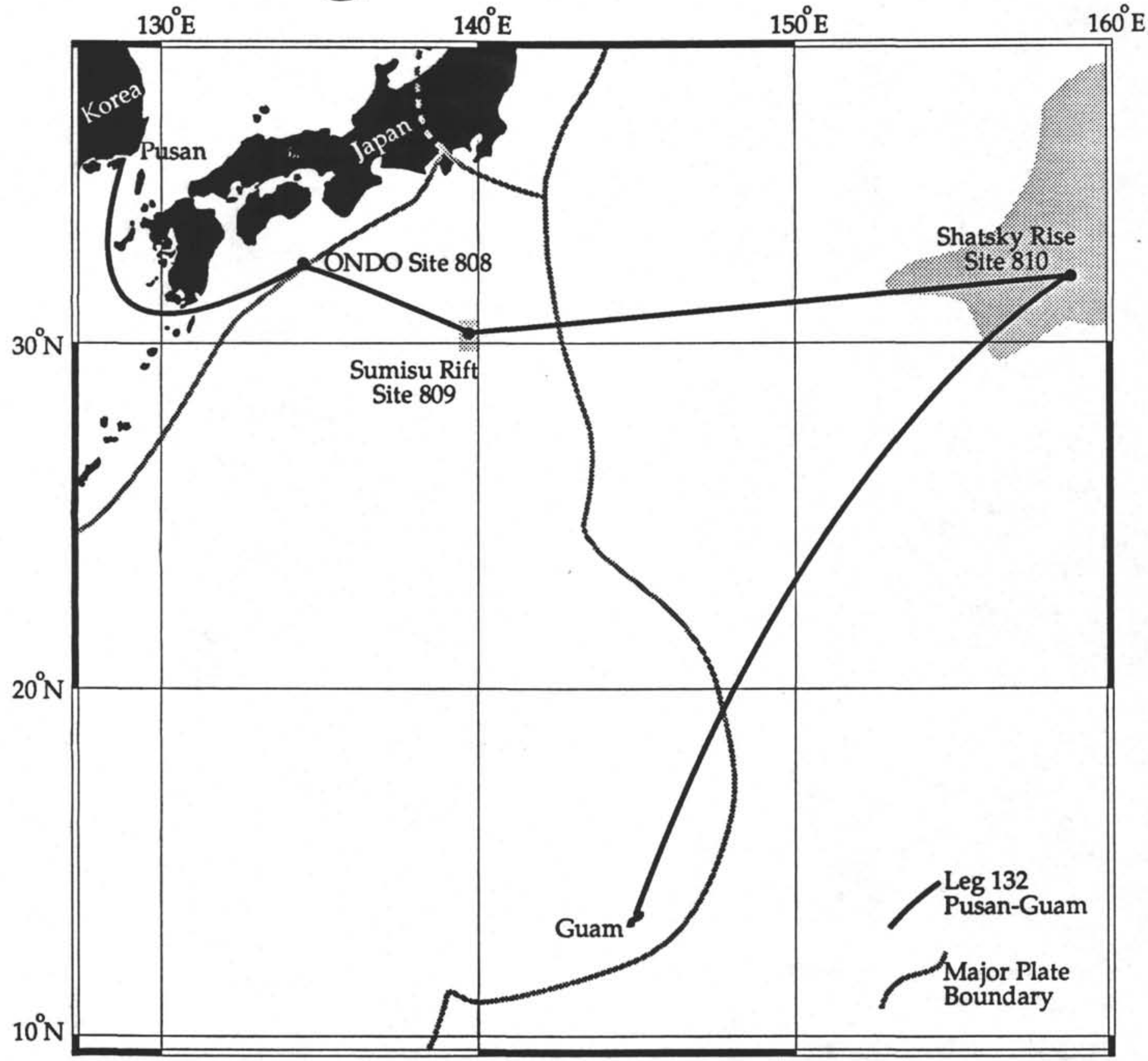


Figure 7

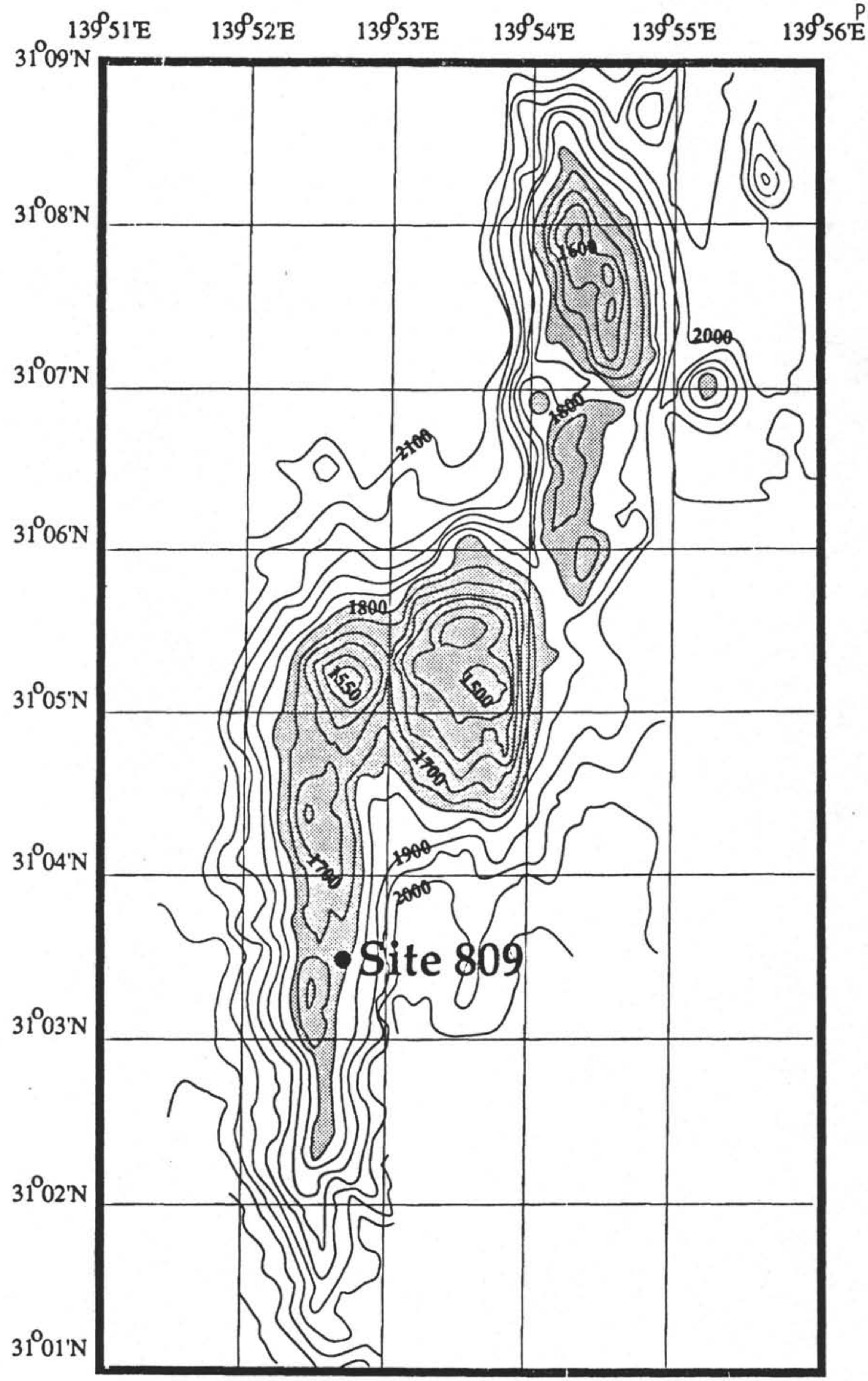

139°51'E
139°52'E
139°53'E
139°54'E
139°55'E
139°56'E
31°09'N
31°08'N
31°07'N
31°06'N
31°05'N
31°04'N
31°03'N
31°02'N
31°01'N
1600
2000
1800
2100
1800
1550
1500
1700
1700
1900
2000
Site 809

Figure 8

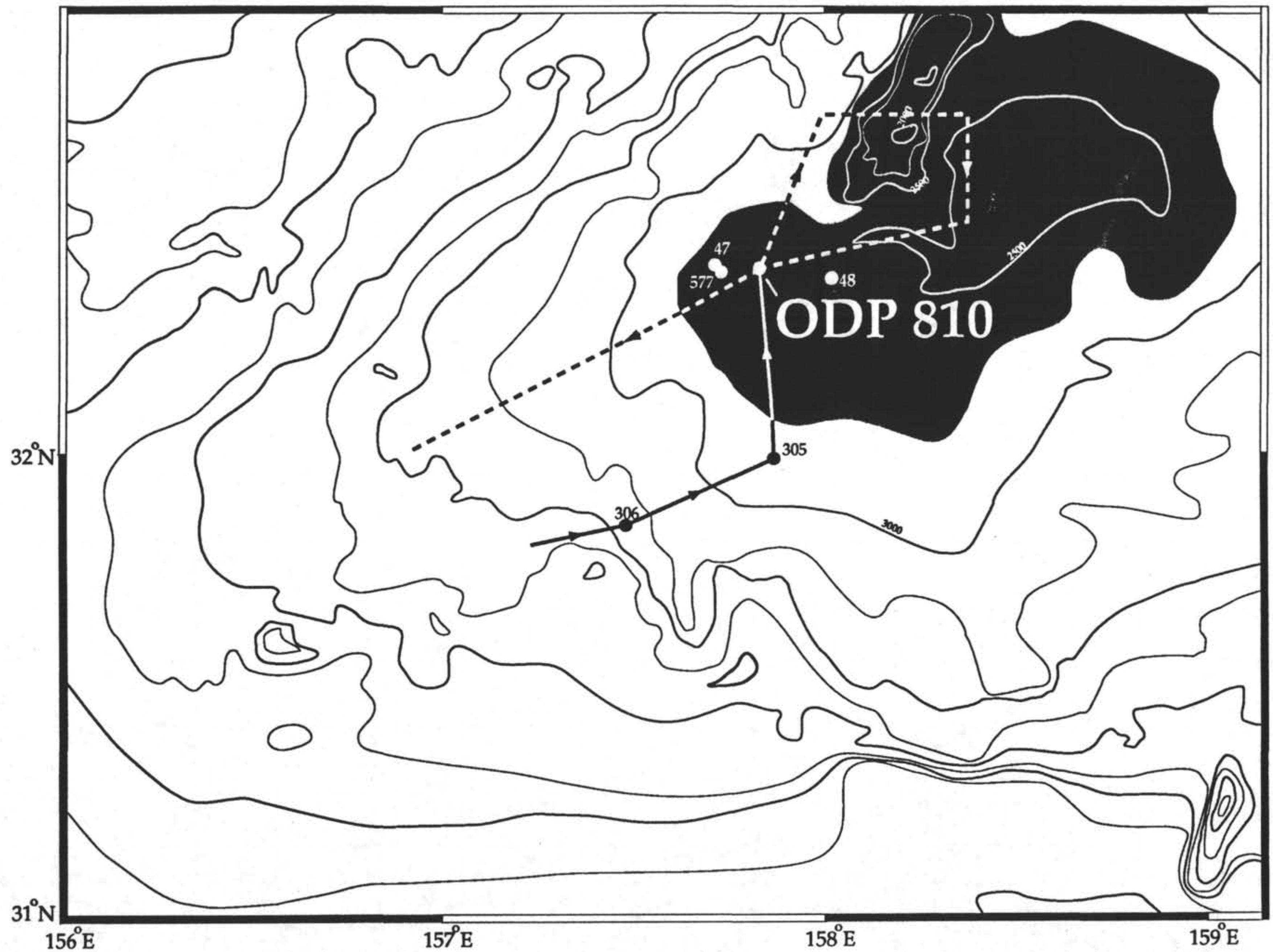
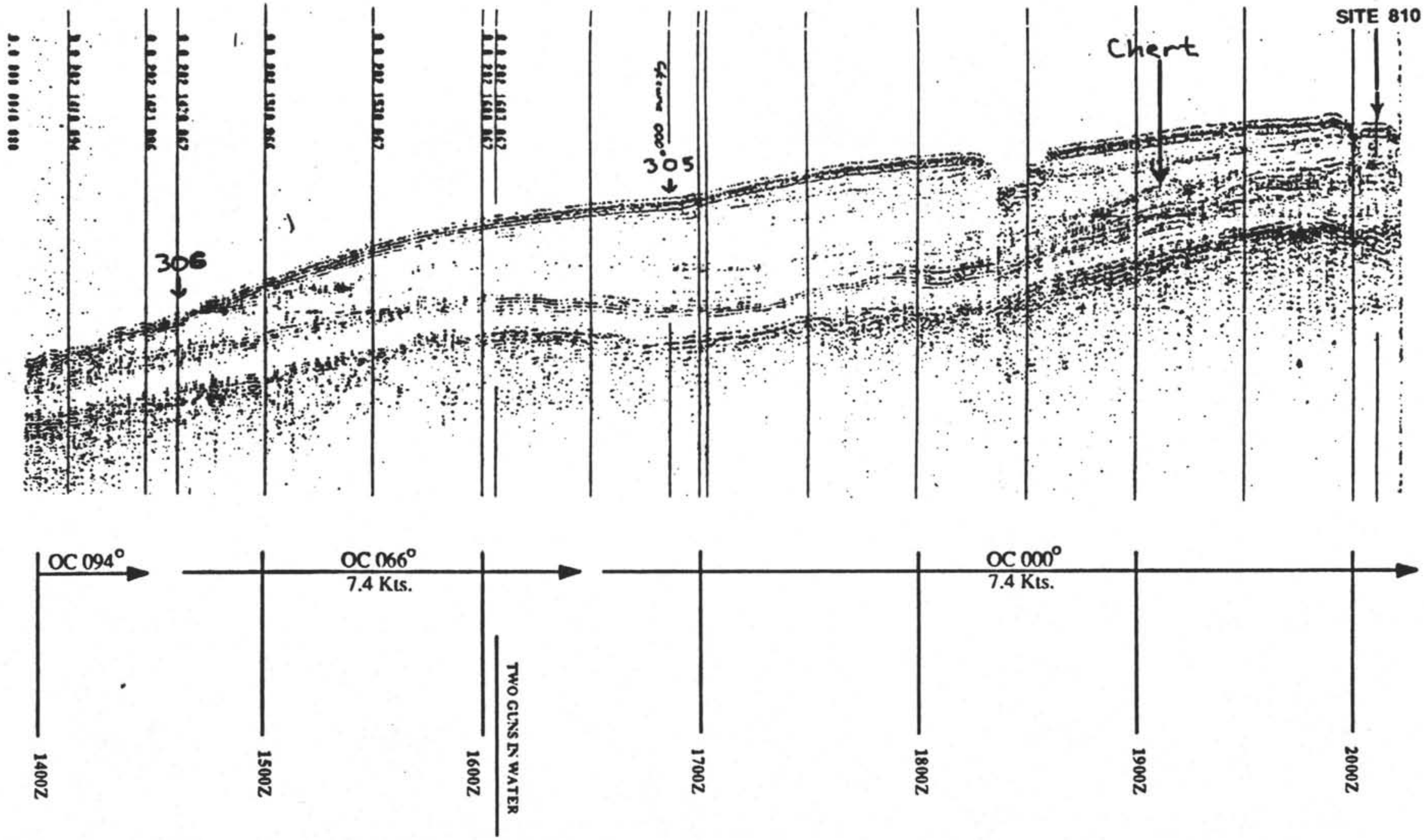


Figure 9



APPROACH TO SITE 810
SHATSKY RISE
21 JULY 1990

Figure 10

SITE 810

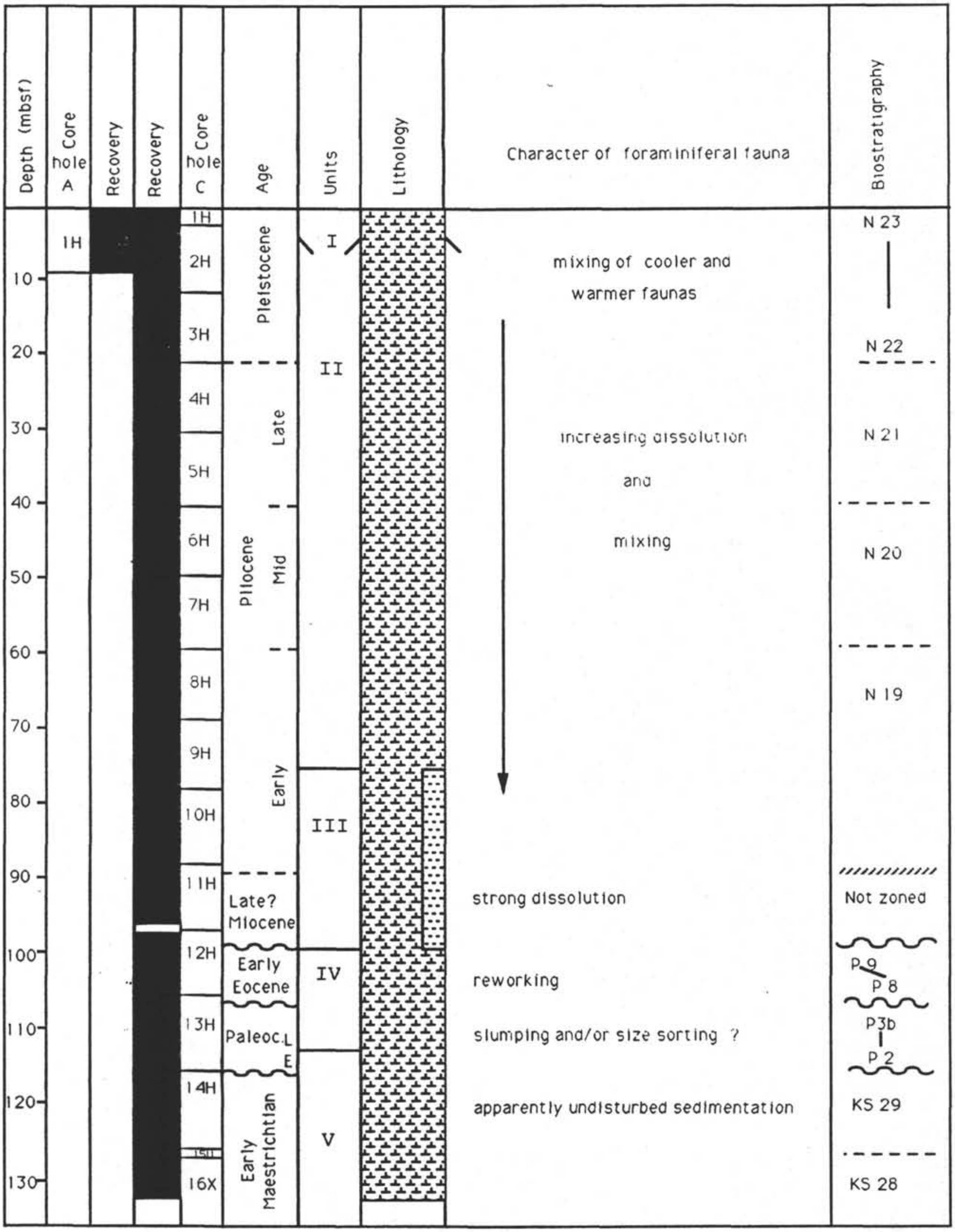


Figure 11

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard *JOIDES Resolution* for Leg 132 of the Ocean Drilling Program were:

Laboratory Officer:	Brad Julson
Asst. Laboratory Officer/ Storekeeper:	Matt Mefferd
Yeoperson:	Michiko Hitchcox
Curatorial Representative:	Steve Prinz
Computer System Manager:	John Eastlund
Electronics Technician:	Barry Weber
Electronics Technician:	William Stevens
Electronics Technician:	Mark Watson
Photographer:	Stacey Cervantes-DuVall
Photographer:	Roy Davis
Chemistry Technician:	MaryAnn Cusimano
Chemistry/Paleomagnetics Technician:	Mark Simpson
X-ray Technician:	Donald Sims
Thin Section/ Marine Geophysics Lab:	Gus Gustafson
Marine Technician/ Marine Geophysics Lab:	Kenneth DuVall
Marine Technician Assistant Curatorial Technician:	Chang-Shik Lee

INTRODUCTION

Leg 132, Engineering Leg II, is the second in a series of cruises designed to support the development and operational refinement of hardware and techniques that will be required to meet the ODP scientific mandate of the future. Since the technical complexity of high-priority scientific problems continues to grow, so too does the demand for dedicated ship time. The engineering goals for Leg 132 included evaluating the diamond coring system (DCS) in problematic geologic environments, and testing new technologies for spudding and controlling unstable formations. The test plan for Leg 132 focused on the ability to spud a hole on bare rock, stabilize fractured or unstable formations, and deploy the DCS for coring operations in crystalline rock, interbedded chalk/chert formations, and in shallow-water carbonate formations prevalent on atolls and guyots. These three environments are usually areas of poor recovery and a successful test in each would provide materials of sufficient coherence and continuity to understand detailed relationships of the lithology, stratigraphy and diagenesis or alteration. The following is a summary of the technical activities that supported the Leg's objectives.

PORT CALL: PUSAN, KOREA

Leg 132 began at 0900 hours, 2 June 1990, when the *JOIDES Resolution* docked in Pusan, South Korea. The technicians moved aboard that first morning and crossed over with the Leg 131 technicians. The port call was unusually busy due to the loading of the diamond coring system (DCS) and laboratory equipment service repairs.

The Applied Research Labs (ARL) factory service representative for our XRF replaced faulty circuit boards, aligned the goniometer reader head, checked all safety interlocks and returned the unit to full operational status. The 2G factory service representative supervised the liquid-helium transfer into the cryogenic magnetometer and addressed minor electronic problems with the system. He also conducted training classes in the operation and maintenance of our magnetometer. Unfortunately an ice block formed during refilling and only 42 liters of helium were loaded into the magnetometer.

The technicians topped off the dewars containing frozen Pressure Core System samples from Leg 131 with liquid nitrogen before shipping the dewars to the States. Technicians immediately unloaded the outbound Leg 131 air freight, but it took a few days to receive all the oncoming freight because of Korean customs delays. The DCS took quite a while to bring aboard and set up. After charging the heave compensator system and testing, we sailed the morning of 8 June 1990.

UNDERWAY LAB: TRANSITS AND SITE SURVEYS

After leaving Pusan, the ship steamed to Site 808 off the southern coast of Japan. We collected standard bathymetric, magnetic, and navigational data. Because we were reoccupying a site that had been drilled and surveyed the previous leg, we did not survey but instead located the site using their beacon's coordinates. Despite a strong current, we occupied the site, successfully deployed the Ondo tool, and then got under way for the Bonin Arc engineering test site. The Bonin site (Site 809) was surveyed for about 7 hr and we collected excellent records despite gun-firing difficulties attributed to problems in the air lines. We used the two new 200 in.^{3} guns, after fitting the oiler lines with a new control valve. The site was in a saddle between two peaks, and we needed to find a relatively flat surface on which to set the HBR guide base. An extensive camera survey of the area was made, and all data recorded on video tape. We also used the Mesotech sonar tool to "see" out farther than the camera. Unfortunately there were problems with its deployment.

About 5 weeks later we departed the Bonin region for the Shatsky Rise site (Site 810) to test the DCS' ability to drill in chert/chalk sequences and recover black shales. After steaming 2 days we arrived at Site 810 and then surveyed for 8 hours with both 200 in.^{3} guns. Key bathymetric horizons were located with the 3.5-kHz transducer. The chert layers from past DSDP legs correlated with our seismic record's, and we drilled the first chert layer at 127 mbsf.

Finally, with time running out and a typhoon bearing down on us, we opted to run a seismic line rather than to go to the third scheduled site (MIT Guyot). We completed a 21-hr seismic survey that tied in our Site 810, a DSDP site, and the highest point on the Shatsky Rise. It intrigued the Chief Scientist to find that the highest point on the Shatsky Rise was a basaltic cone that he suspects is an old guyot. We quickly battened down the hatches and sailed into the fringes of Typhoon Steve as we headed for Guam.

OPERATIONS SUPPORT

ONDO Operations at Site 808 went smoothly, and the Japanese engineers were able to deploy their tool down the hole without the current-induced vibrations loosening any of the connections as experienced on Leg 131. We successfully reentered Hole 808E using the Mesotech tool. The ambient noise of the *JOIDES Resolution* made ONDO tool verification inconclusive, but the Japanese engineers were optimistic of its success.

The technicians provided assistance to the engineers during the DCS deployment by photo-documenting the DCS operations, filming most of the reentries, fabricating everything from containers for the computers, to slings, to air fittings, running telephone cables to the DCS platform and insuring they had an operational reentry system. Technicians set up computers in the downhole measurements lab to troubleshoot the secondary heave-compensation program and assisted with repairing the erasable-programmable read only memory (EPROM) burner.

LAB WORK

This leg was an engineering leg and quite different in many aspects from a typical scientific leg. Because of the small amount of core that came aboard, the technicians took advantage of the available time to cross train and get to know their labs and equipment better. They studied documentation and tested new methods in a way that cannot be done on a busy, standard scientific leg. Technicians performed in-depth preventative maintenance and alignment on many instruments that there usually isn't time to perform.

Core, Magnetics, and Physical Properties Labs

During the first half of the leg, extensive modifications were made in the core-splitting room. The floor installed during the dry dock in Singapore never cured to the point of becoming hard and rigid. Instead, the floor always remained soft and pliable, and anything left on it soon "sank" into the floor. We removed all of the soft material and cleaned the base plate. A series of epoxy and grout layers were laid down until the floor level was back to its original height. The floor was painted, and non-skid footing installed. The Felker saw base frame and sediment trap were sanded and painted. We also painted the Core Entry Area.

The Chief Scientist requested that we change the format of core photos for Leg 132. Since DCS cores are only 3 m long, we decided to cut the sections 75 cm long (rather than 150 cm) and move the core table closer to the camera lens. This change increased the magnification, allowing more core detail to be shown. We had to revert to the original setup when we drilled the APC cores.

We initially used the physical properties lab for 2-min GRAPE runs for the samples collected from the Hess Deep on an Alvin dive. Compressional wave velocities were measured on these same samples using the Hamilton Frame device. High-frequency proxy climatic signals were measured on the APC cores from Shatsky Rise using the MultiSensor Track (MST). Magnetic-susceptibility readings were taken at 3-cm intervals for 10 seconds using the more sensitive 0.1 scale. This took up to two hours per core and created a brief core back log. At one point the MST boat kept binding in the P-wave logger (PWL) transducers causing the program to halt. The problem was alleviated by increasing the compumotor torque. A new spread sheet type data entry was requested from the computer group on shore to speed up the flow of cores and measurements in the physical properties lab and increase productivity. We attached a printer to the pycnometer to capture the data in hard copy form.

The magnetics lab ran smoothly this leg. A new technician was trained during the port call to monitor the cryogenic magnetometer and run samples.

Paleontology and Thin Section Labs

Only four scientists used the paleontology lab during Leg 132, but the lack of material recovered allowed them substantial time to work on samples brought from shore. Initially there was some confusion about setting up one of the scopes for reflective light, but a telex from the beach identified a part that Zeiss failed to mention in their documentation. The parts for the microscopes were extensively interchanged between labs and microscopes, and it was a challenge inventorying the parts at the end of the Leg.

Thirty samples were processed for thin sections during Leg 132. Twenty of these were the Chief Scientist's samples from a dredge haul in the East Pacific Rise.

Chemistry and X-ray Lab

The chemistry lab was used primarily for analysis of geriatric cores and for material recovered at the APC hole (Hole 810C). Geriatric samples were brought out from the Gulf

Coast Repository dating back to DSDP Leg 2, and other geriatric samples were taken during the leg. A dedicated hole was devoted to the geriatric study (Hole 810A), and samples were analyzed immediately, then after one day, and finally after one week. An Anion Micro Membrane Suppressor was installed in the Dionex with a pressurized regenerate system. The Dionex is now fully automated with the Lab Automation System. Final concentrations are produced using a multilevel calibration of standard concentrations on batches of samples that run for over 18 hours at a time. The Dionex underwent extensive maintenance this leg. Parts were ordered to repair the Spectrophotometer which will be used as a backup to a new unit that is scheduled to be installed on Leg 134. A power surge at the beginning of the Leg took out a resistor in the Carle GC. It was replaced and the Carle returned to service. We calibrated all 3 GC's. Many samples were run on the CarbonNitrogenSulfur analyzer, and experiments using capsules made from aluminum and tin were conducted. Aluminum boats have less of a tendency to fuse with the columns and cause them to become brittle and break. We tested the Rock-Eval extensively, and changed many components.

The x-ray fluorescence (XRF) unit was returned to working order after an ARL representative visited the ship during the port call. He replaced a board, configured the XRF to run only goniometer 2, and aligned the reader head for goniometer 2. He also calibrated the vacuum gauge and the temperature-control board. During the leg we recalibrated the XRF. Most of the samples analyzed were brought out by the Chief Scientist; both major and minor elements were analyzed. Late in the leg the silica values appeared to be running a little high; this was investigated on the way to Guam.

<u>Computers and Curation</u>

Owing to the few scientists on this leg, the computer-user room saw little use. This gave the opportunity for many individuals, including the System Manager, to test and become proficient on software programs that they had not had time to learn in the past. A new revision of the MST program in the phys props lab arrived aboard one of the rendezvous vessels.We loaded it on the MST PC's and not only did it solve many problems noted in the past, it also gave us greater capabilities than the old program. Digitized scanned pictures of the reentry cone as viewed through the downhole camera were sent to ODP. These pictures were enhanced in a drawing program and sent to ODP over satellite communication. We replaced the worn carpet tiles in the Computer User Area with new tiles; also new chairs were installed in the same area. We encountered communications problems trying to BLAST our telexes to shore. Evidently the shore VAX had a disk crash, and it took a while to put all the necessary files back into the communication account so we could communicate with the shore. The maglaser printer was down for most of the leg. The ETs swapped components with the User Room laser printer until the problem was isolated, and new parts were ordered for repair for the maglaser.

The Curatorial Representative was busy this leg with changes in core handling. The DCS core and liners are smaller than those we normally process. Consequently the core-liner cutters, core-splitting saw, and end caps had to be changed in size. If it is decided to employ both the DCS and our standard drilling methods during the same leg, as we did this leg, we will need two sets of equipment. Changes in core diameter also affect the MST, the cryogenic magnetometer, and sample sizes for curation. We tried a new epoxy mixer/applicator for hard-rock labeling this leg and everyone agreed it was an improvement over the old method. A new version of SAMUTIL software also arrived during the leg.

This was the second leg to take a core for the geriatric study. A one-core hole was drilled for this study (Site 810). Samples were taken to be analyzed for changes in chemistry, mineralogy, paleontology, physical properties, etc. over time. The sampling and testing frequency was immediately, the next day, and a week later. We will continue these studies on shore.

Photo and Electronics Labs

The photo lab was busy this leg, as two photo technicians sailed to document the workings of the DCS. Both 3/4-in. and 1/2-in.videotape was used to film the DCS, as well as standard color slides and black and white prints. It's not easy hanging up in the derrick, loaded down with video equipment trying to film a small, tightly packed, moving DCS floor. The photographers also worked closely with the industry representatives in getting the needed photo documentation to all parties involved.

The ET's were busy during this leg keeping the VIT camera and the Mesotech sonar unit running. The camera was the main tool that made it possible for us to reenter the cones as often as we did. We set a record this leg when we reentered the throat of the gimbaled Hard Rock Base after the cone had been knocked off. We lacked any choice but to try and reenter a tube only 3 feet wide. Though we had uncommonly mild weather for extended periods, this proved that future cones can be constructed smaller. The coaxial TV cable is quickly deteriorating and in need of replacing. On many deployments of the camera, strands of the exterior armor would come unraveled, and we would have to cut away the broken strands as the camera was brought up slowly to the surface. Because more and more of the cable's armor was being cut away, we were concerned about its strength, and at one point we moved the cable grip about 30 meters up the cable. With so much camera use and a scarcity of reterminating supplies on board, we simply wrapped the excess 30 meters of cable in a tight roll on top of the VIT frame. We never had to reterminate the cable again.

We videotaped all reentries and TV surveys for future ODP use. A scientist made an edited version of the tapes, which included a section when a large, deep-water shark cruised ominously through the camera's view.

Special Projects

We replaced the feed and return cooling water lines to the Birdwell air-conditioning unit for the marine geophysics lab. The flow through the lines had slowly become more and more restricted to the point that larger lines were required and installed. This made the lab more comfortable in warm weather. Past cruises reported frequent problems with condensation and lack of adequate air conditioning in warm, moist air environments. It is always a fine line to balance the temperature of cooling water in order to provide enough cool air to keep the lab comfortable, but not so much that condensation drips from the ducts.

The marine emergency technical squad (METS) took part in weekly drills with the SEDCO fire-fighting team. The highlight of the trip was the use of fire extinguishers on an actual fire in a drum on the aft end of the heliport.

LEG 132 STATISTICS

General:

Sites: 2
Holes: 10
Meters Cored: 204.6
Meters of Core Recovered: 164.7
Number of Reentries: 28
Number of VIT Camera Deployments: 30
Number of Samples: 679

Analysis:

Physical Properties:
- Index Properties: 239
- Velocity: 38
- Vane Shear: 71

Chemistry:
- Carbon/Carbonate: 228
- Gas: 7
- IW: 25
- Thin Section: 30

Underway Geophysics:

Total Transit: 3252 nmi
Bathymetry: 3215 nmi
Magnetics: 2857 nmi
Seismics: 216 nmi